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NATIONAL DAM SAFETY PROGRAM. UPPER KESWICK DAM (NJ-00047), ATLA--ETC(U)
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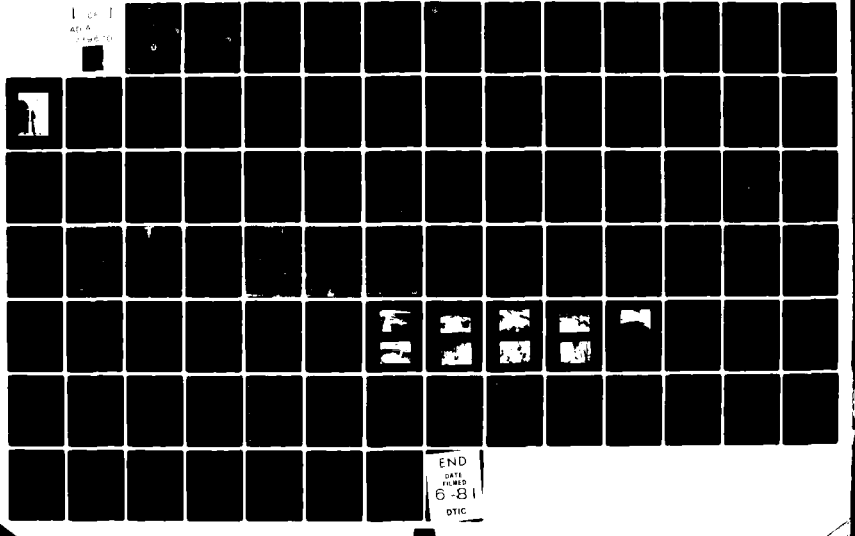

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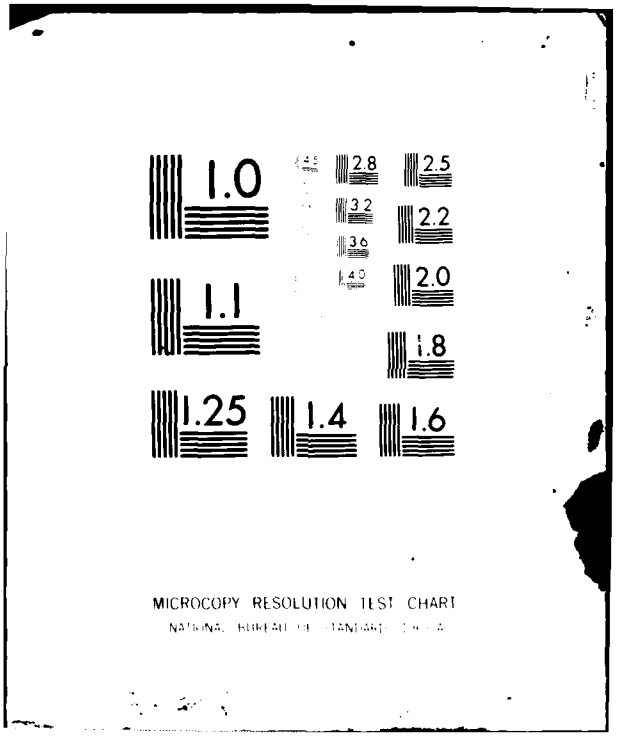
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LEVEL

ATLANTIC COASTAL BASIN,
WRANGEL BROOK, OCEAN COUNTY,
NEW JERSEY.

UPPER KESWICK DAM
NJ 00047

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DACW61-79-C-0011

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia Pennsylvania

Rept. DAEN/NAP/53842/NJ00047-81/05

MAY 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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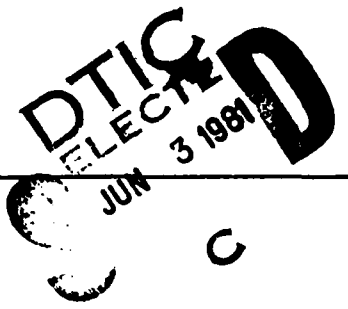

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams	National Dam Safety Program
Embankments	Spillways
Visual Inspection	Outlet works
Structural Analysis	Embankment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

28 MAY 1981

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Upper Keswick Dam in Ocean County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Upper Keswick Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 43 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within twelve months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. The following remedial actions should be initiated within twelve months from the date of approval of this report:

(1) The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

(2) Construct a concrete headwall and apron at the outlet end of the discharge pipe.

(3) Fill in the eroded area of the embankment with suitable material and seed the section.

(4) All trees and brush should be removed from the side slopes to avoid problems which may develop from roots. The embankment face should then be reseeded to develop a growth of grass for surface erosion protection.

(5) Determine the size of the sluice gate and whether or not it is operable, and if not, institute remedial action to make it operable.

(6) Investigate the embankment for animal burrows and fill in any burrow holes with impervious material.

c. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam, within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Hughes of the Second District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

KENNETH R. MOSER
Major, Corps of Engineers
Acting District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

UPPER KESWICK DAM (NJ00047)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 8 January 1981 by Harris-ECI Associates under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Upper Keswick Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 43 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within twelve months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. The following remedial actions should be initiated within twelve months from the date of approval of this report:

(1) The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

(2) Construct a concrete headwall and apron at the outlet end of the discharge pipe.

(3) Fill in the eroded area of the embankment with suitable material and seed the section.

(4) All trees and brush should be removed from the side slopes to avoid problems which may develop from roots. The embankment face should then be reseeded to develop a growth of grass for surface erosion protection.

(5) Determine the size of the sluice gate and whether or not it is operable, and if not, institute remedial action to make it operable.

(6) Investigate the embankment for animal burrows and fill in any burrow holes with impervious material.

c. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam, within one year from the date of approval of this report.

APPROVED: Kenneth R. Moser

KENNETH R. MOSER
Major, Corps of Engineers
Acting District Engineer

DATE: 28 May 1981

ATLANTIC COASTAL BASIN

WRANGEL BROOK, OCEAN COUNTY

NEW JERSEY

UPPER KESWICK DAM

NJ00047

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

PHILADELPHIA, PENNSYLVANIA 19106

MAY, 1981

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name:	Upper Keswick Dam, I.D. NJ 00047
State Located:	New Jersey
County Located:	Ocean County
Stream:	Wrangel Brook
River Basin:	Atlantic Coastal Basin
Date of Inspection:	January 8, 1981

Assessment of General Conditions

Upper Keswick Dam is an earthfill dam with a paved roadway along the crest and a concrete capped timber drop inlet as a spillway. The overall condition of the dam is good. There are no major signs of distress or instability in the embankment. Minor seepage was observed at three different locations along the downstream toe. One location was to the left of the downstream channel and the others at each end of the dam. The low-level outlet was not open at the inspection and is not used. The hazard potential is rated as "high".

Upper Keswick Dam is considered inadequate in view of its lack of spillway capacity to pass the SDF (1/2 PMF) without overtopping the dam. The spillway is capable of passing a flood equal to 21 percent of the PMF (42 percent of the 1/2 PMF), and is assessed as "inadequate".

At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory. The following actions are recommended along with a timetable for their completion. All recommended actions should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. Based on the results of these studies, remedial measures should be instituted. This should include the installation of a tailwater gage.

2. The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

3. Construct a concrete headwall and apron at the outlet end of the discharge pipe. This work should be completed within twelve months.

4. Fill in eroded area of embankment with suitable material and seed the section within twelve months.

5. All brush and trees should be removed from the downstream and upstream slopes to avoid problems which may develop from roots. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. This program should be started within twelve months.

6. Determine the size of the sluice gate and if it is operable. If not, institute remedial action to make it operable within twelve months.

7. Investigate embankment for animal burrows and fill in any burrow holes with impervious material.

8. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

Furthermore, while of a less urgent nature, the following additional action is recommended and should be carried out within twelve months.

The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

John P. Talerico, P.E.
HARRIS-ECI Associates

Photo taken January 8, 1981

U P P E R K E S W I C K D A M

View looking from right end of dam. Drop inlet is located just beyond end of brush along upstream (left) slope.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

PLATES

APPENDICES

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

UPPER KESWICK DAM, I.D. NJ 00047

S E C T I O N 1

1. PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FPM No. 35 with the State of New Jersey who, in turn, is contracted to the Philadelphia District of the Corps of Engineers, and was carried out by the engineering firm of Harris-ECI Associates of Woodbridge, New Jersey.

b. Purpose of Inspection

The visual inspection of Upper Keswick Dam was made on January 8, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Upper Keswick Dam is an earthfill dam 296 feet long and 12.4 feet high with a 21 foot wide paved roadway along the top of the dam. There is a 9.3 foot by 6.5 foot concrete capped timber drop inlet with a timber trash rack across the top located 177 feet from the left end of the dam. The crest of the lake side section of the inlet is 3 inches below the sidewalls and 2.3 feet below the top of roadway. The flow from the spillway discharges into the downstream channel through a 60-inch by 66-inch reinforced concrete pipe which also serves as the low-level outlet.

The embankment has a top width of 30 feet with approximate slope of 3.5H:1V on both faces. The upstream slope has a timber bulkhead extending from the spillway 30 feet to the left and 15 feet to the right.

The low-level outlet consist of the 60-inch x 66-inch reinforced concrete pipe that carries the discharge from the spillway. The low-level flow into the pipe is controlled by a small rising stem sluice gate located on the upstream face of the drop inlet. The gate is raised manually by turning a handwheel attached to the top of the frame that sits on a timber platform attached to the lakeside face of the spillway.

The outlet end of the pipe discharges into the downstream channel approximately 45 feet from the inlet. The downstream channel continues for a distance of 600 feet where it crosses under a timber roadway bridge and enters into Lower Keswick Lake. The bridge is 42 feet long and has five short spans, with the height from the bottom of the bridge to the water varying from 4.7 feet at the center to 2.7 feet at the abutments.

A generalized description of the soil conditions is contained in Report No. 8 Ocean County, Engineering Soil Survey of New Jersey by Rutgers University. The report dated 1953, indicates the immediate area of the lake and dam to be stratified recent alluvium, with the surrounding areas being alluvial stratified materials underlaid with marine stratified materials. Recent alluvium can be described as materials usually assorted by water-action and ranging in size from silt with some clay, to silt and fine sand with gravel. Alluvial stratified materials can be described as assorted, relatively homogeneous materials composed predominantely of gravel and sand sizes. Marine is described as assorted homogeneous materials, ranging in texture from a uniform medium to coarse sand. The depth to bedrock in these desposits is greater than 100 feet. Geologic Overlay Sheet 32 describes the bedrock around the lake as the Tertiary formation of Cohansey Sand.

b. Location

Upper Keswick Lake Dam is located in Keswick Grove, which is an Alcoholic Rehabilitation Center, on Wrangel Brook, in the Township of Manchester, Ocean County, New Jersey. It is accessible from Route 70 at Whiting by way Pinewald-Keswick Road (Route 530) to Congasia Road at Keswick Grove.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineers, the dam is classified in the dam size category as being "small", since its storage volume of 123 acre-feet is less than 1,000 acre-feet. The dam is also classified as "small" because its height of 12.4 feet is less than 40 feet. The overall size classification of Upper Keswick Dam is "small".

d. Hazard Classification

A hazard potential classification of "high" has been assigned to the dam on the basis that a hypothetical failure would result in excessive damage to the main dining hall and the chapel located within the flood reach along Lower Keswick Lake, and to the six other buildings located, also within the flood reach, downstream of the Lower Lake. Therefore, the possibility exists of the loss of more than a few lives in the event of dam failure.

e. Ownership

Upper Keswick Dam is owned by:

America's Keswick
Keswick Grove
Whiting, NJ 08759

Attention: Mr. William A. Raws
General Director
(201) 350-1187

f. Purpose

Upper Keswick Dam is presently used for recreation purposes only.

g. Design and Construction History

Upper Keswick Dam was constructed in 1898. On March 30, 1938, the spillway failed by undermining and settling, washing out a 60 foot section of the embankment. No records exists as to whether or not there was damage downstream due to the failure. In rebuilding the embankment timber sheeting was driven along the length of the failure to a depth 12 feet below the spillway invert to prevent future undermining. The reconstruction of the dam was completed in August, 1938.

h. Normal Operating Procedures

The discharge from the lake is unregulated and allowed to naturally balance the inflow into the lake. According to the center's resident engineer, the low-level outlet is not used.

1.3 Pertinent Data

a. Drainage Area	0.89 sq. mi.
b. Discharge at Dam Site	
Ungated spillway capacity at elevation of top of dam:	486 (96.66 NGVD)
Total spillway capacity at maximum pool elevation (SDF):	1,541 (97.5 NGVD)
c. Elevation (Feet above NGVD)	
Top of dam:	96.66
Maximum pool design surcharge (SDF):	97.5
Recreation pool:	93.4
Spillway crest:	93.4
Streambed at centerline of dam:	83.3 (Estimated)
Maximum tailwater:	88 (Estimated)
d. Reservoir	
Length of maximum pool:	2,250 feet (Estimated)
Length of recreation pool:	1,300 feet (Estimated)
e. Storage (acre-feet)	
Spillway Crest:	54
Top of dam:	123
Maximum pool (SDF):	148
f. Reservoir Surface (acres)	
Top of dam:	26
Maximum pool (SDF):	31
Recreation pool:	16.5
Spillway crest:	16.5 (93.44 NGVD)

g. Dam

Type:	Earthfill with concrete capped timber drop inlet
Length:	296 ft.
Height:	12.4 ft.
Top width:	30 ft.
Side slopes - Upstream: - Downstream:	3.5H:1V 3.5H:1V
Zoning:	Unknown
Impervious core:	None
Cutoff:	None
Grout curtain:	None

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Concrete capped timber drop inlet with notched front side
Length of weir:	25.0 ft.
Crest elevation:	93.44 (NGVD)
Gates:	None
U/S Channel:	Upper Keswick Lake
D/S Channel:	Natural Channel

j. Regulating Outlets

Low level outlet:	60-inch x 66-inch R.C.P.
Controls:	Manually controlled small sluice gate
Emergency gate:	None
Outlet:	83.4 NGVD

SECTION 2

2. ENGINEERING DATA

2.1 Design

A drawing showing the new outlet pipe and timber sheeting details for the reconstruction of the Upper Keswick Dam in 1938 and a drawing showing details of the spillway, prepared in 1973 by the Center's Resident Engineer, are available in his files at America's Keswick, Keswick Grove, Whiting, NJ. No data from soil borings, soil tests, design computations, or other geotechnical data is available to assess the stability properly. Data concerning the hydraulic capacity of the spillway is also unavailable.

2.2 Construction

Data is not available concerning the as-built construction or reconstruction of the dam. No data exists of construction methods, borrow sources, or other data pertinent to the construction of the dam.

2.3 Operation

Formal operation records are not kept for the dam and reservoir. The lake is allowed to operate naturally without regulation.

2.4 Evaluation

a. Availability

The availability of engineering data is poor. The stated drawings are available from the owner.

b. Adequacy

The engineering data available, together with that obtained in the field, was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform a stability analysis, but preliminary evaluation could be made based on visual observations.

c. Validity

Information contained in the drawings and checked by limited field measurements appears to be valid.

SECTION 3

3. VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection of Upper Keswick Dam revealed the dam and spillway to be in good condition, but in need of repairs. At the time of inspection the lake level was just above the crest of the spillway.

b. Dam

The earth embankment appears sound. Minor surface cracking on the pavement was noted, but cracks are tight. No cracking at the toe was noted. One area of erosion approximately 55 feet left of outlet was noted on the downstream slope. No misalignment of the embankment in the horizontal or vertical plane was evident. Minor seepage in the way of ponding and wet ground was noticed at the downstream toe of the embankment in three different locations. The seepage was occuring along an 18 foot wide section approximately 120 feet left of the spillway; a 15 foot wide section approximately 40 feet left and at a point approximately 160 feet right of the spillway. Numerous trees are growing on the downstream face of the embankment and a few trees and brush are growing on the upstream slope. No evidence of burrowing by animals was observed; however, the embankment was covered with snow and therefore the possibility does exist that there may be burrow holes.

c. Appurtenant Structures

1. Spillways

The spillway is in good condition. No cracks in the concrete caps were noted only spalling. The timber trash rack appeared in good condition.

2. Outlet Works

The low-level outlet works is also the spillway. It consists of the drop inlet with a small rising stem sluice gate, operated by a handwheel attached to the top of the frame at the upstream face of the inlet, and a 60-inch by 66-inch reinforced concrete pipe that discharges the flow into the downstream channel. There is a concrete headwall at the inlet of the pipe and timber headwall across the top and at the right side of the outlet. There is some spalling of the concrete headwall, while the lower part of the timber wall on the side is missing resulting in erosion of the slope along the pipe.

d. Reservoir Area

The side slopes surrounding the reservoir are flat and sandy with a dense cover of pine trees. There is no indication of slope instability.

e. Downstream

The downstream channel from the spillway to the lower lake is in good condition. The channel widens from approximately 10 feet at the outlet to 40 feet plus/minus at the timber bridge located 600 feet downstream from the outlet. There are some tree stumps and timber branches along the bottom of the channel. The side slopes are flat and heavily wooded. The area is used for nature walks as there are timber plank walks and benches on both sides of the channel.

There are two buildings located above the flood plain left of the downstream channel. On the right bank of the lower lake are the main dining hall and chapel as well as six other camp buildings just downstream of the lower lake that are within the flood plain.

SECTION 4

4. OPERATIONAL PROCEDURES

4.1 Procedures

Upper Keswick Dam is used to impound water for recreational activities. The level of the lake is maintained through the unregulated flow over the main spillway.

4.2 Maintenance of the Dam

There is no regular inspection and maintenance program for the dam and appurtenant structures. America's Keswick is responsible for the maintenance of the dam.

4.3 Maintenance of Operating Facilities

The low-level outlet operating facilities consist of one manually operated small sluice gate. At the time of inspection, the operation of the gate was not demonstrated. According to the resident engineer, the gate has never been open in the ten years he has been at the center, therefore he does not know if the gate is operable.

4.4 Evaluation

The present operational and maintenance procedures are fair with the dam and spillway being maintained in a serviceable condition.

SECTION 5

5. HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Upper Keswick Dam is approximately 0.89 square miles. A drainage map of the water shed of the dam site is presented on Plate 1, Appendix D.

The topography within the basin is generally mildly sloped. Elevations range from approximately 167 feet above NGVD at the north end of the watershed to about 93 feet at the dam site. Land use patterns within the watershed are mostly woodland.

The evaluation of the hydraulic and hydrologic features of the dam was based on criteria set forth in the Corps guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for the Dam falls in a range of 1/2 PMF to PMF. In this case, the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low-side of their respective ranges.

The Probable Maximum Flood (PMF) was calculated from the probable maximum precipitation using Hydrometeorological Report No. 33 with standard reduction factors. Due to the small drainage area, the SCS triangular hydrograph transformed to a curvilinear hydrograph was adopted for developing the unit hydrograph, with the aid of the HEC-1-DB Flood Hydrograph Computer Program.

Initial and constant infiltration loss rates were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC-1-DB.

The SDF peak outflow calculated for the dam is 1,541 cfs. This value is derived from the half PMF, and results in overtopping of the dam, assuming that the lake was originally at the spillway crest elevation.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam utilizing HEC-1 Dam Safety Version Program.

The reservoir stage-storage capacity relationship was computed directly by the conic method, utilizing the HEC-1-DB program. The reservoir surface areas at various elevations were measured by planimeter from a U.S.G.S. Quadrangle topographic map. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based

on the assumption that the dam remains intact during routing. The spillway rating curve is presented in the Hydrologic Computation, Appendix D.

A breach analysis indicates that the stage of the stream where it crosses the center's road at the beginning of the Lower Lake is 2 feet higher, due to dam failure from overtopping at 0.3 PMF than it would be without failure at 0.3 PMF. This does not jeopardize the road downstream significantly more than without failure. The discharge facility is thus rated "inadequate".

Drawdown calculations could not be done due to the size of the gate is unknown and could not be determined at the time of inspection.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site.

c. Visual Observations

The downstream channel is in good condition. It widens from 10 feet at the outlet to approximately 40 feet at the timber bridge at the beginning of the Lower Lake. The side slopes are flat and heavily wooded. The area is also used for nature walks.

There are two buildings on the right shore of the Lower Lake and six others immediately downstream.

The side slopes surrounding the reservoir are flat and sandy with a dense cover of pine trees. There is no indication of slope instability.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 0.84 feet. Computations indicate that the dam can pass approximately 21 percent of the PMF without overtopping the dam crest. Since the 1/2 PMF is the Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps of Engineers, the spillway capacity of the dam is assessed as "inadequate".

SECTION 6

6. STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There are no major signs of distress in the embankment of the Upper Keswick Dam. Minor seepage was observed along the toe of slope at three different locations; at the left and right ends of the embankment and approximately 40 feet left of the downstream channel. The seepage has not been monitored and no information was uncovered concerning its flow rates. The numerous trees growing on both sides of the embankment could pose a threat to stability. The spillway was in good condition.

b. Design and Construction Data

No design computations relating to stability were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment.

c. Operating Records

No operating records are available relating to the stability of the dam.

d. Post-Construction Changes

There are no known post-construction changes since the dam was rebuilt in 1938.

e. Static Stability

A static stability analysis was not performed for Upper Keswick Dam because the lack of data on which to base assumptions of material properties within embankment zones might produce misleading results, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory.

f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist, and based on the findings of the visual inspection, the preliminary assessment of the static and seismic stabilities is that they are satisfactory.

S E C T I O N 7

7. ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase 1 report.

Upper Keswick Dam is inadequate because the dam does not have the spillway capacity to pass the SDF, one half of the PMF, without overtopping. Overtopping of the dam carries with it the danger of a likely progressive failure of the dam. The present spillway capacity of the dam is approximately 21 percent of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment material engineering properties, but based on the findings of the visual inspection, preliminary assessment of the static stability is that it is satisfactory.

b. Adequacy of Information

The information uncovered was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even an approximate computation of the stability of the dam. A preliminary assessment of the dam could be made by visual observation only.

c. Urgency

The remedial measures and recommended actions along with a timetable for their completion are detailed below. All recommended action should be conducted under the supervision of an engineer who is experienced in the design, construction and inspection of dams.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the embankment height of the dam thus permitting a higher discharge to pass.

2. Lower the spillway crest elevation.

3. Increase the effective spillway crest length.

4. A combination of any of the above alternatives.

b. Recommendations

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.

2. The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

3. Construct a concrete headwall and apron at the outlet end of the discharge pipe within twelve months.

4. Fill in eroded area of the embankemnt with suitable material and seed the section within twelve months.

5. All trees and brush should be removed from the side slopes to avoid problems which may develop from roots. The embankment face should then be reseeded to develop a growth of grass for surface erosion protection. This program should be started within twelve months.

6. Determine the size of the sluice gate and whether or not it is operable, and if not, institute remedial action to make it operable within twelve months.

7. Investigate embankment for animal burrows and fill in any burrow holes with impervious material.

The following additional action is recommended:

The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

c. O & M Procedures

The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

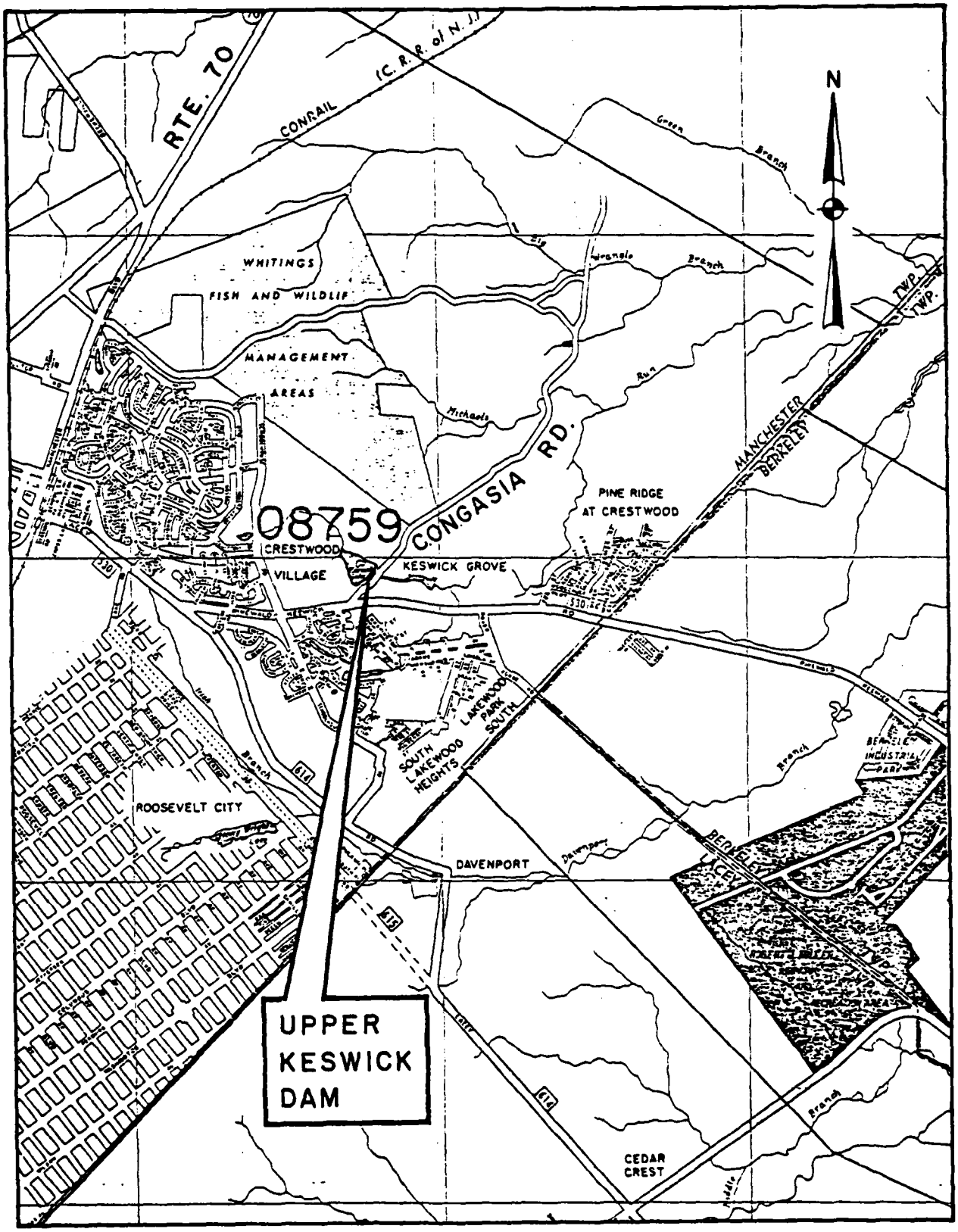
PLATES

UPPER KESWICK DAM

MANCHESTER TOWNSHIP
OCEAN COUNTY, N. J.

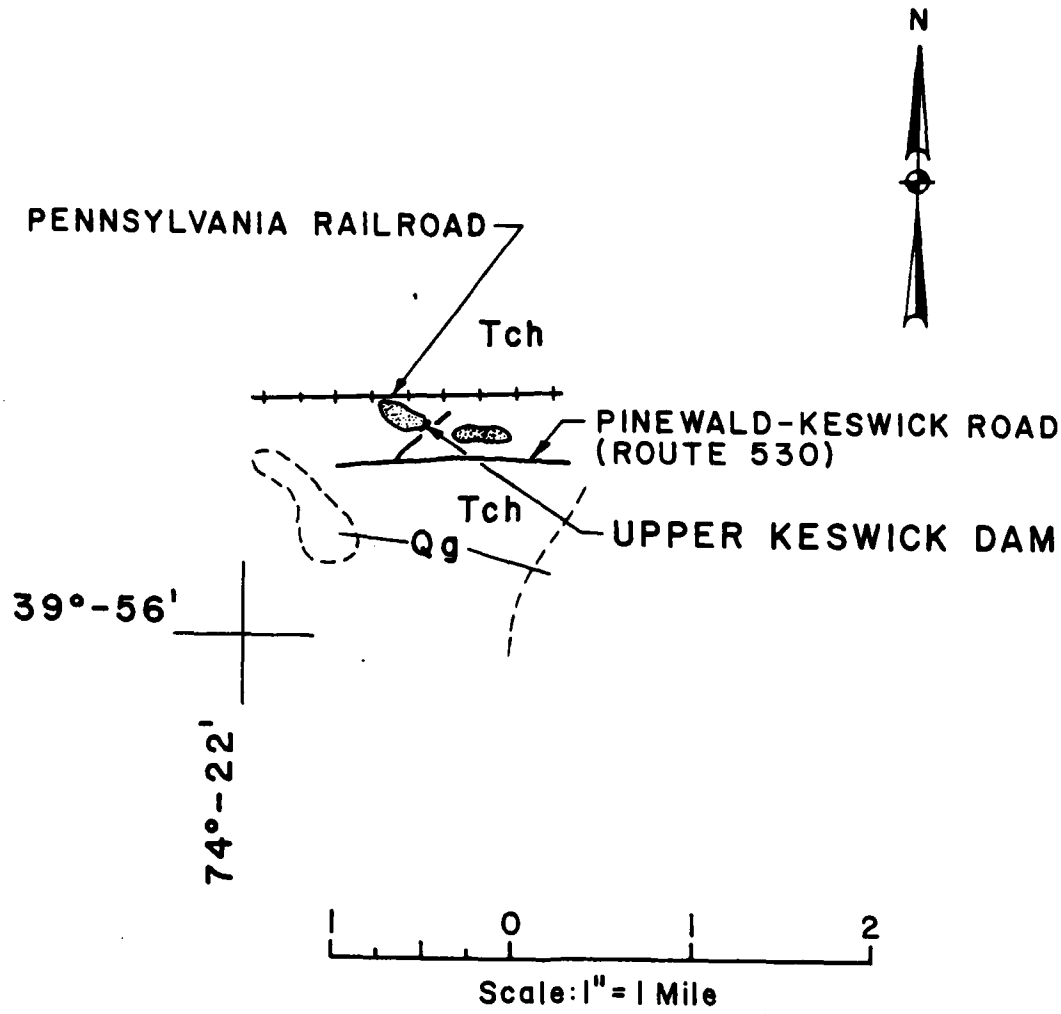
KEY MAP

PLATE 1



VICINITY MAP

PLATE 2



LEGEND

QUATERNARY

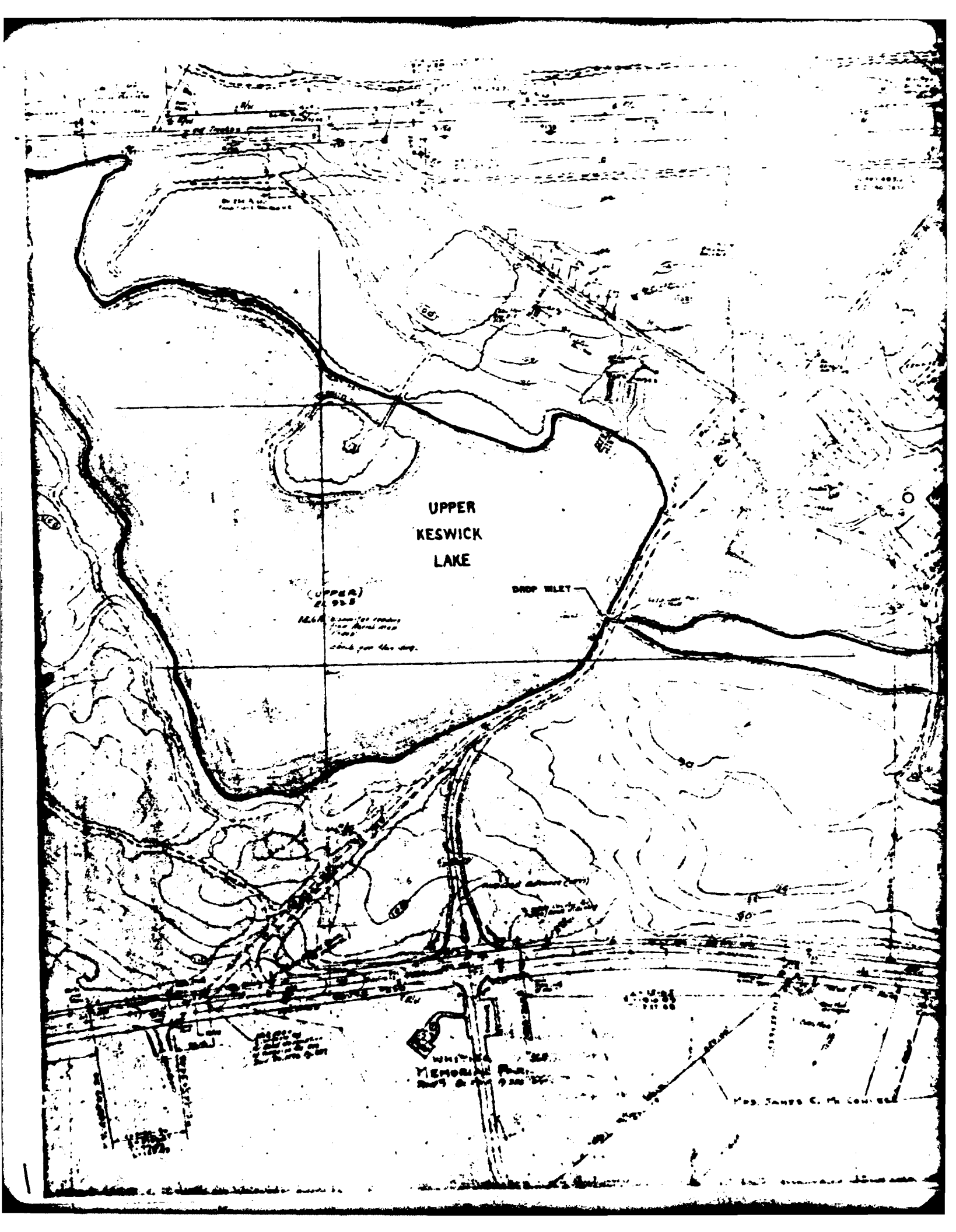
Qg Gravel

TERTIARY

Tch Cohansey Sand

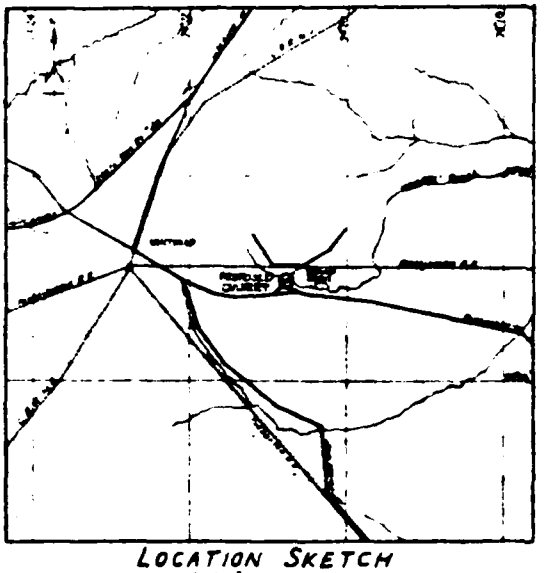
GEOLOGIC MAP
UPPER KESWICK DAM

PLATE 3

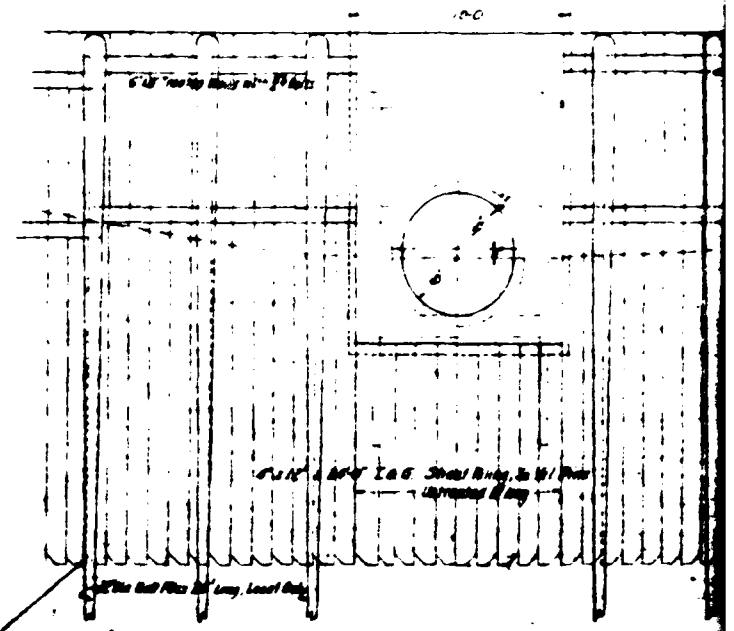

UPPER
KESWICK
LAKE
DROP INLET


KESWICK (Lower)
LAKE
AMERICAN KESWICK

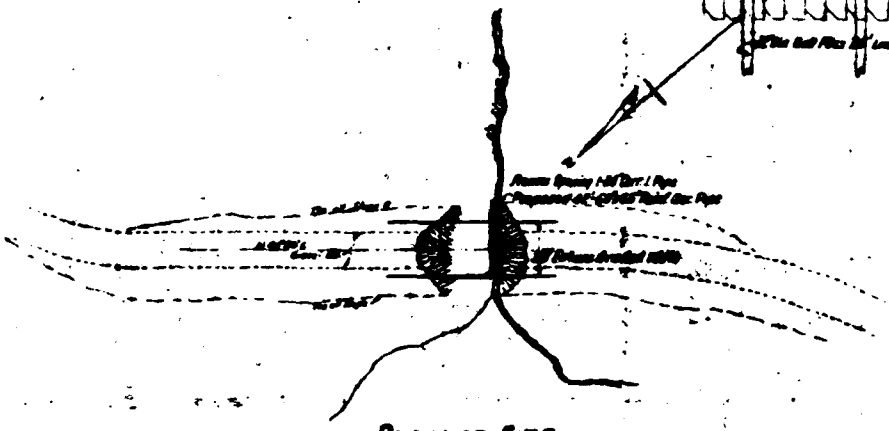
PLATE 4



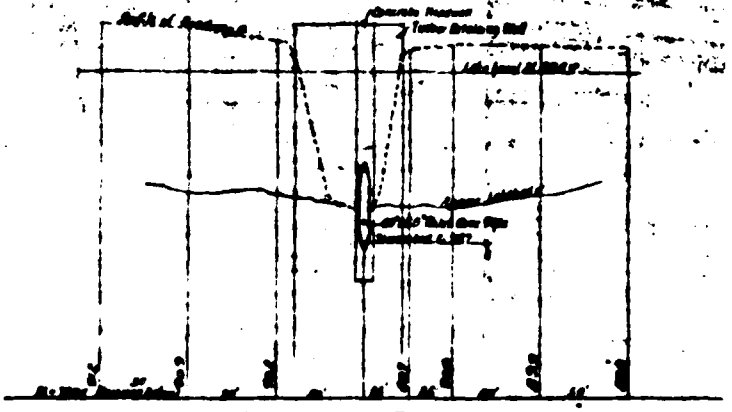
LOCATION SKETCH



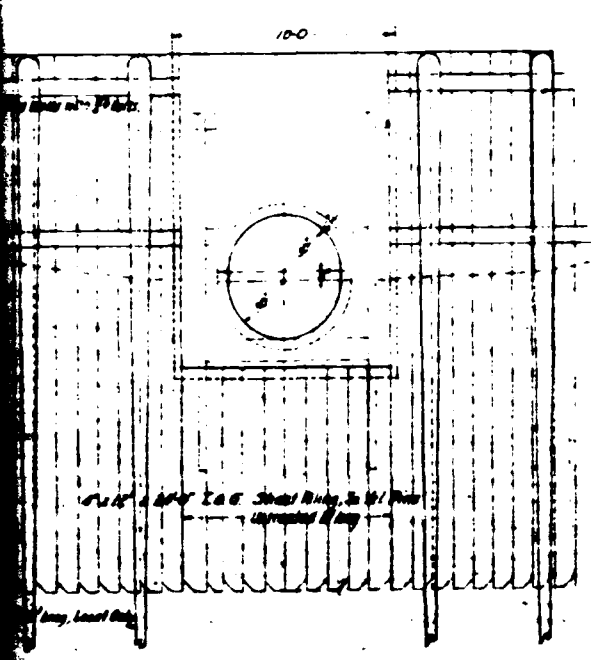
SECTION B-B



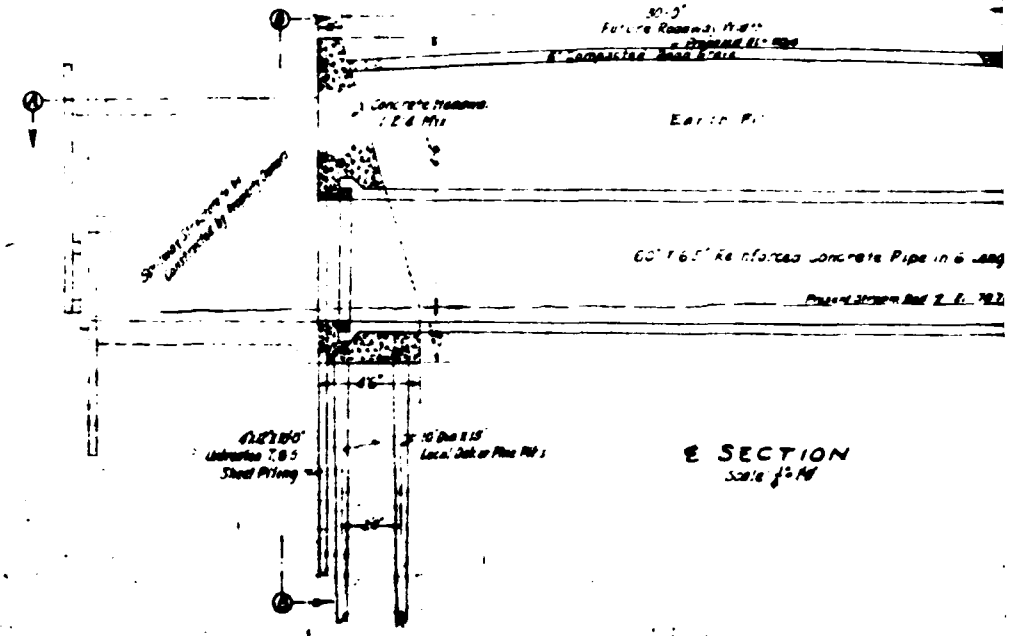
PLAN OF SITE



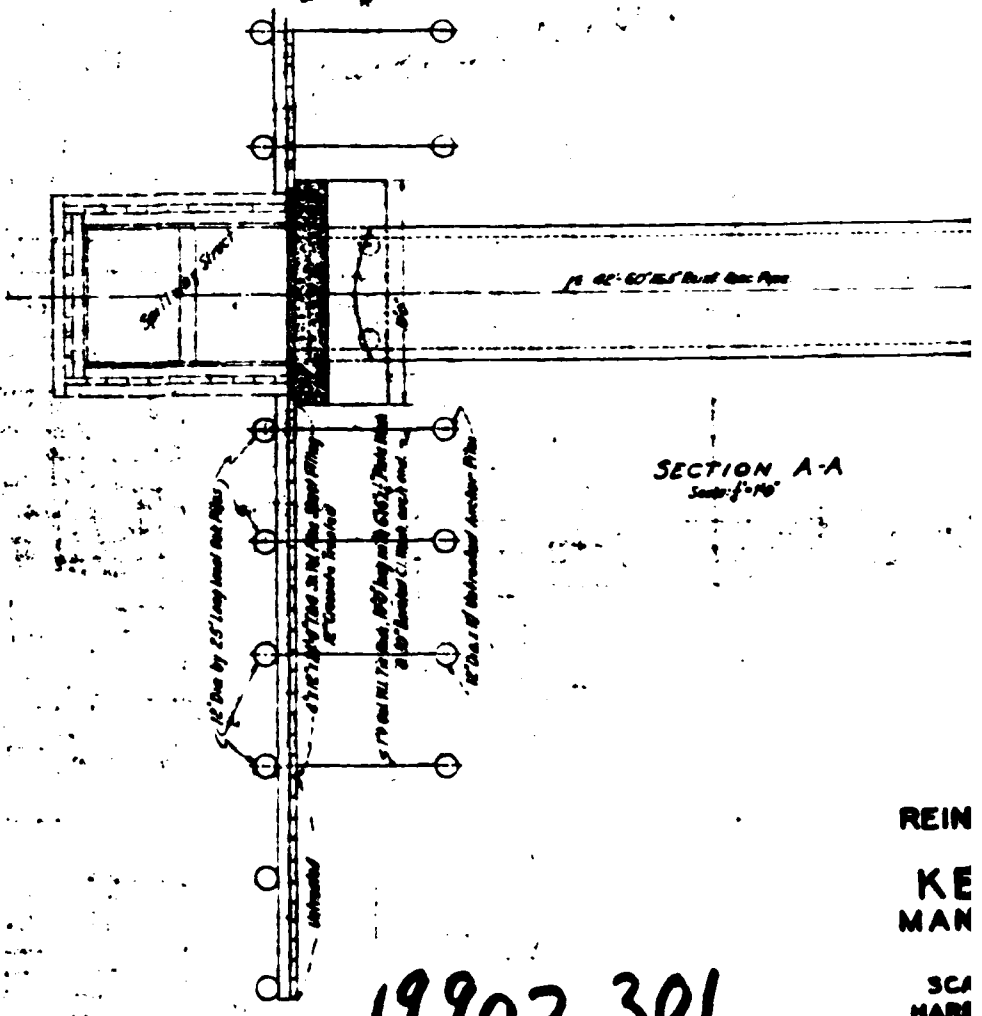
PROFILE OF ROADWAY



SECTION B-B
Scale 1/2"=1'-0"



E SECTION
Scale 1/2"=1'-0"



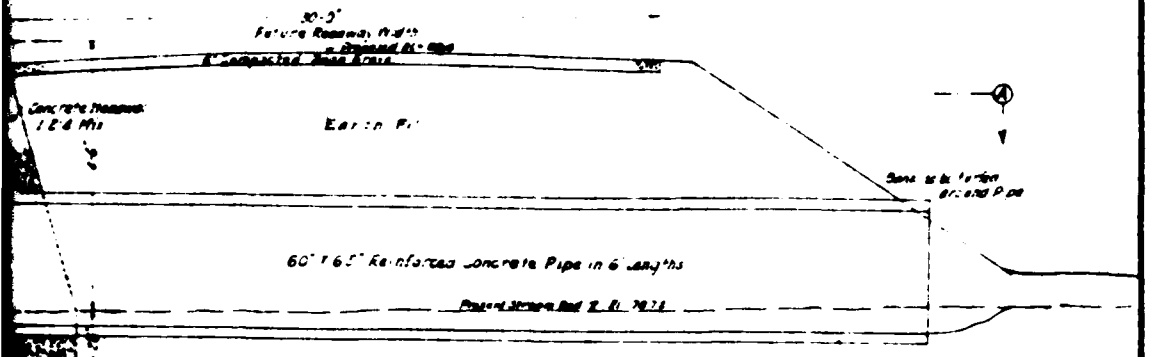
SECTION A-A
Scale 1/2"=1'-0"

REIN

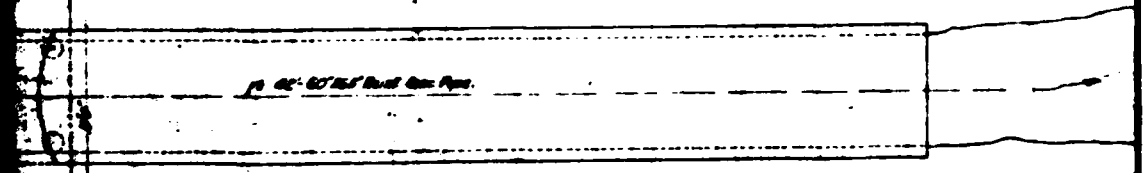
KE
MAN

SCA
HAR

19902301



℄ SECTION



SECTION A-A

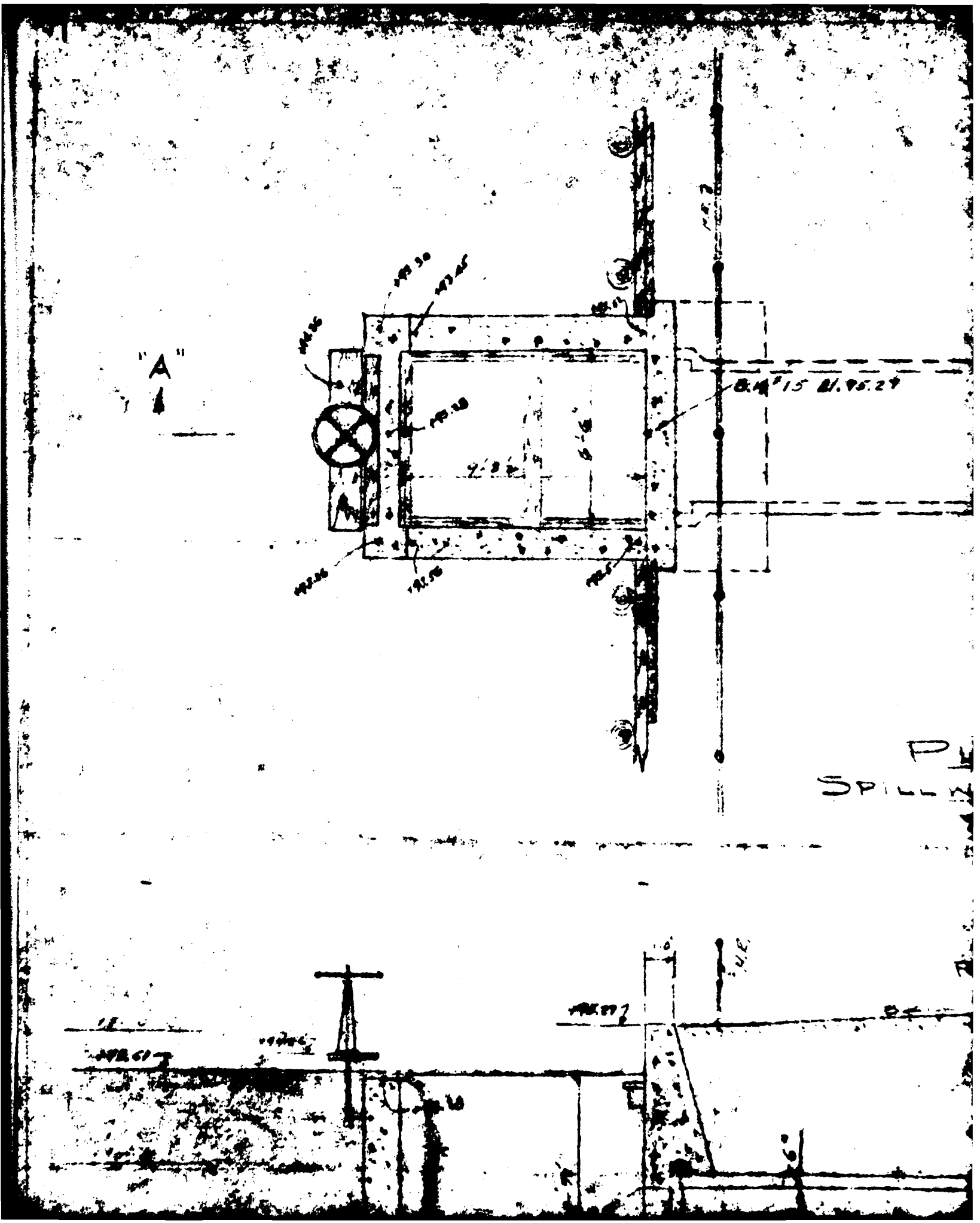
PLANS OF
REINF. CONC. PIPE CULVERT
AT
KESWICK GROVE
MANCHESTER TOWNSHIP
OCEAN COUNTY

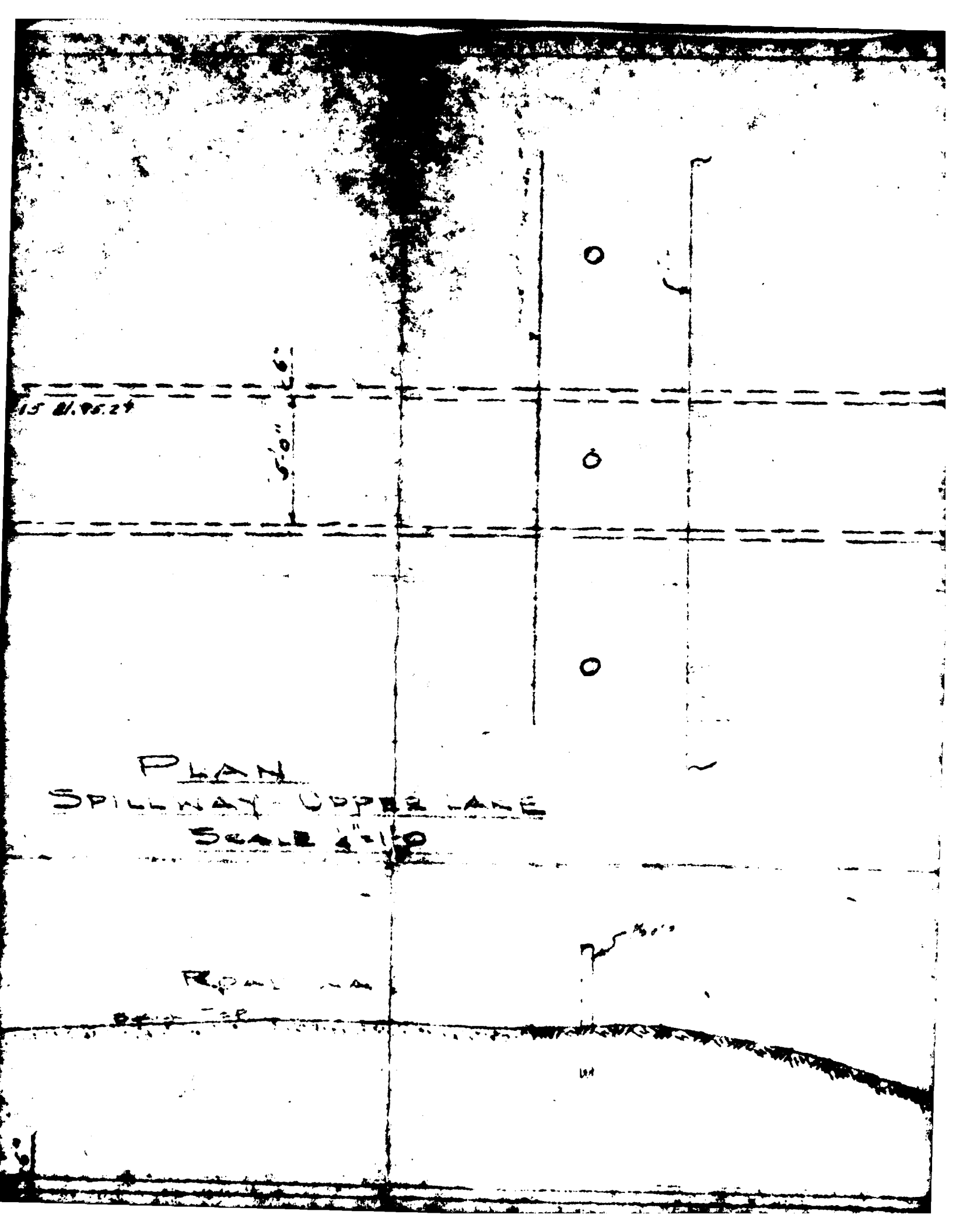
SCALES AS SHOWN MAY 1938

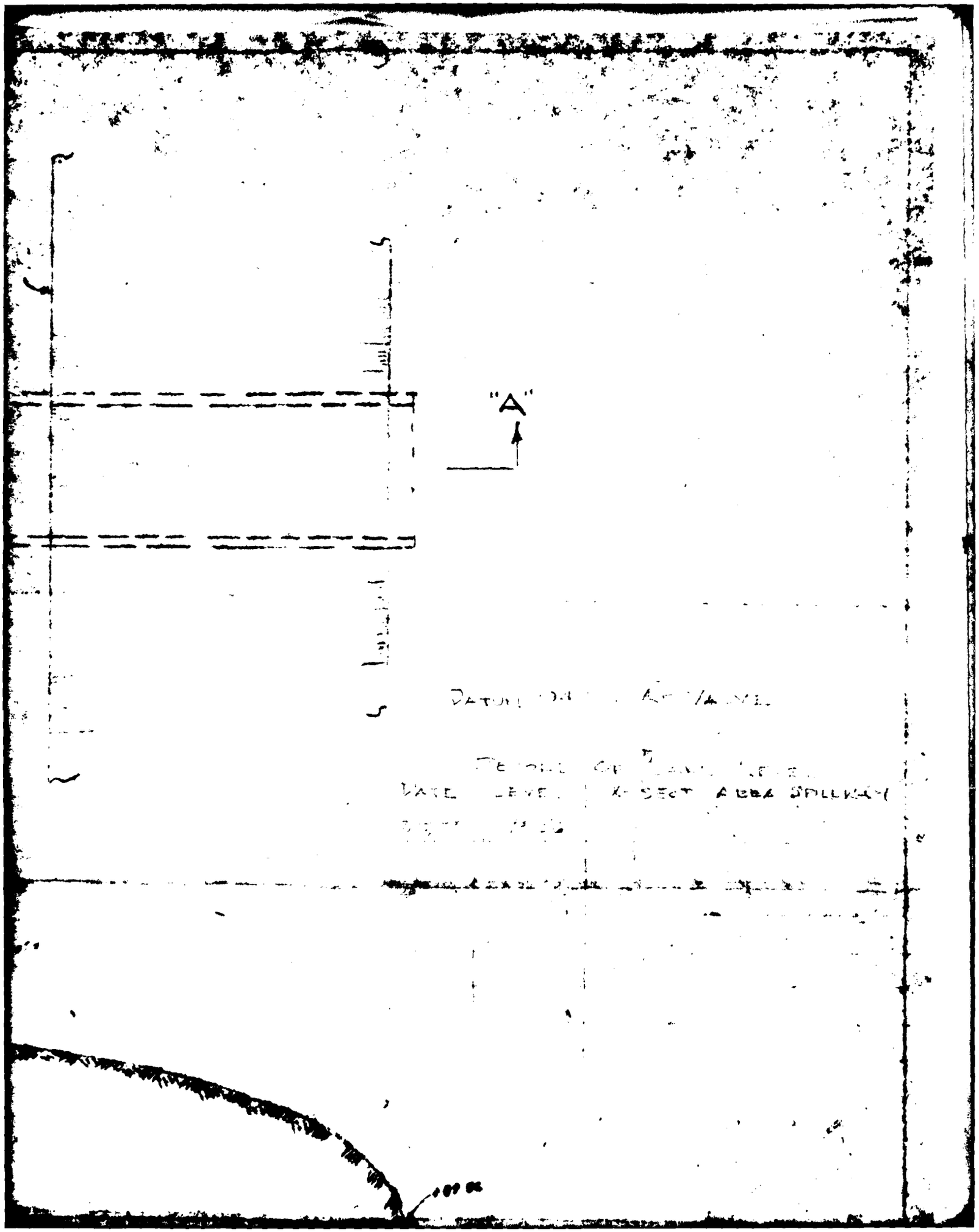
HARRY C. SHINN COUNTY ENGINEER

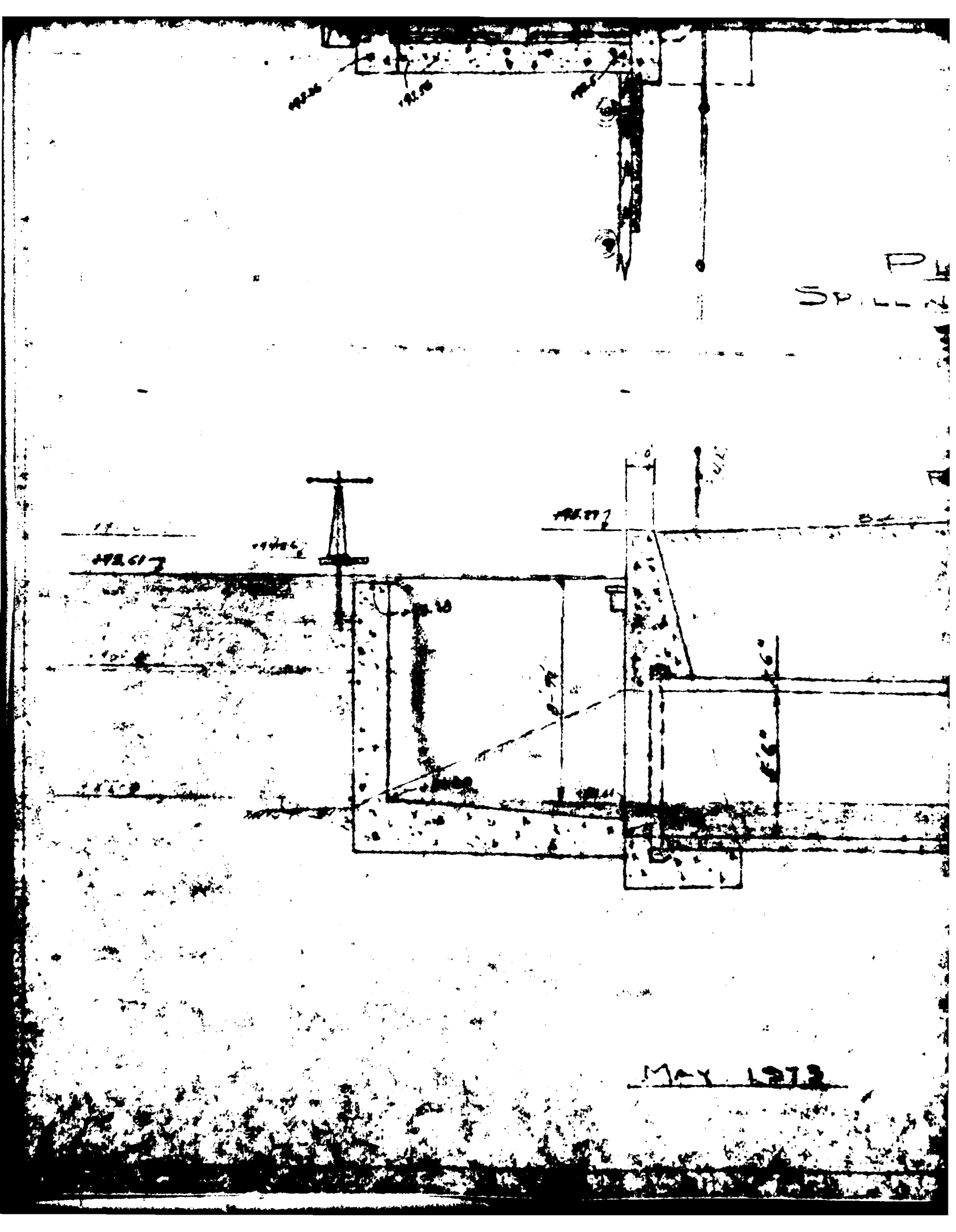
PLATE 5

19902301


"A"
SPILL

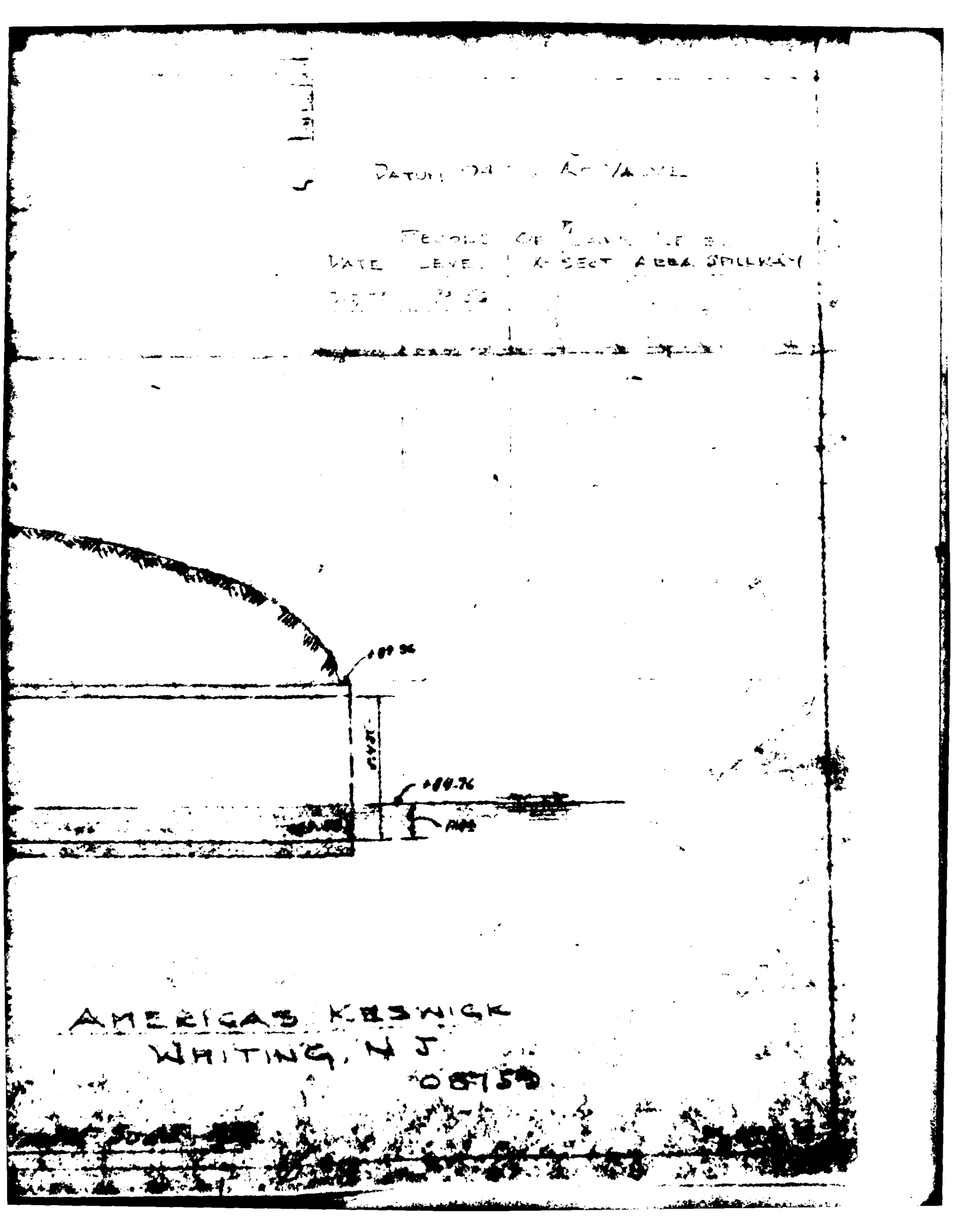

15 El. 95.24
5'-0"
PLAN
SPILLWAY - UPPER LAKE
SCALE 1"=10'


"A"


SPILL
MAY 1973

PLAN
SPILLWAY - UPPER LANE
SCALE 1"=50'

SECT A-A


AMERICAN KEWICK
WHITING, N J
08759

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE 1

Name Dam Upper Keswick Dam County Ocean State New Jersey Coordinators NJ-DEP

Date(s) Inspection January 8, 1981 Weather Clear Temperature 5°F

Pool Elevation at Time of Inspection 94.11 NGVD Tailwater at Time of Inspection 85.77 NGVD

Inspection Personnel:

January 8, 1981

William Birch
Thomas Moroney
Joseph Sirianni (Recorder)

Owner
OWNER/REPRESENTATIVE:

January 8, 1981

Michael Sudol
Resident Engineer
Keswick Grove
Whiting, NJ 08759

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS	Top of embankment is a paved road. Some minor cracks in pavement. Cracks were tight.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noticed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion at one downstream location left of spillway. Erosion appears to be caused by runoff from road.	Refill eroded area with appropiate materials and seed area.
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST	Horizontal and vertical alignments good.	
RIPRAP FAILURES	None	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
EARTH EMBANKMENT	Heavy growth of trees and brush on downsteram slope. Some tree and brush growing on upstream slope near top.	Remove trees and brush.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition.	
ANY NOTICEABLE SEEPAGE	Minor seepage was visible at downstream toe at three locations. 1. A 15-foot wide area of soft wet ground 40+ feet left of spillway. 2. A 18-foot wide section of ponded water. 120± feet left of spillway. 3. An area 160±feet right of spillway-very slight flow.	Monitor seepage for clearance and quantity.
STAFF GAGE AND RECORDER	None	
DRAINS	None	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	N/A - Spillway (also outlet works) discharges directly in downstream channel.	
INTAKE STRUCTURE	Spillway is drop inlet with sluice gate, spalling of top and inside faces of concrete caps.	
OUTLET STRUCTURE	60-inch x 66-inch reinforced concrete pipe in good condition. Concrete headwall at inlet with timber headwall across top and right side of pipe at outlet. Lower part of timber wall on side gone and slope eroded along the pipe.	Fill in eroded area with appropiate materials. Provide concrete headwall and apron for pipe.
OUTLET FACILITIES	None	
EMERGENCY GATE	None	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR	Spillway is a timber drop inlet with concrete cap and sluice gate- top and inside faces of caps are spalled	
APPROACH CHANNEL	Lake is approach channel for spillway.	
DISCHARGE CHANNEL	60-inch by 66-inch reinforced concrete pipe, in good condition, is discharge channel and low-level outlet.	
BRIDGE AND PIERS	Timber trash rack across top of inlet is in good condition.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/ SURVEYS None		
OBSERVATION WELLS None		
WEIRS None		
PIEZOMETERS None		
OTHER None		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES Flat with heavy growth of pine trees.		
SEDIMENTATIONS None visible.		

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Channel in good condition with some tree stumps and branches along bottom. Channel widens from approximately 10 feet at the outlet to 40 feet at the bridge at beginning of lower lake.	
SLOPES	Flat and heavily wooded. Area is also used for nature walk as there are board walks and benches on both sides of channel.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Two buildings(out of flood plain)left of channel, two main buildings (dining hall and chapel) on right shore of lower lake and also six other camp buildings downstream of lower lake.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None Available.
REGIONAL VICINITY MAP	Available - Ocean County Map and U.S.G.S. Quadrangle Sheet for Keswick Grove, New Jersey
CONSTRUCTION HISTORY	Original dam built 1898, spillway rebuilt 1938, no other information available.
TYPICAL SECTIONS OF DAM	None available.
HYDROLOGIC/HYDRAULIC DATA	None available.
OUTLETS - PLAN	Available at Resident Engineer's office-America's Keswick Keswick Grove, Whiting, NJ 08759
- DETAILS	Not available.
- CONSTRAINTS	None
- DISCHARGE RATINGS	Not available.
RAINFALL / RESERVOIR RECORDS	Not available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None Available.
GEOLOGY REPORTS	Available U.S.G.S. Geologic Overlay Sheet No. 32 and Engineering Soils Survey of New Jersey, Report No. 8 Ocean County, by Rutgers University (New Brunswick, NJ)
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	Unknown.
SPILLWAY PLAN - SECTIONS	Available at Resident Engineer's office-Keswick Grove
- DETAILS	None available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	None available
MONITORING SYSTEMS	None
MODIFICATIONS	None
HIGH POOL RECORDS	None kept.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	Spillway & dam failed in 1938 due to undermining and settling.
MAINTENANCE OPERATION RECORDS	None known to exist.

APPENDIX B

PHOTOGRAPHS

(Taken on January 8, 1981)

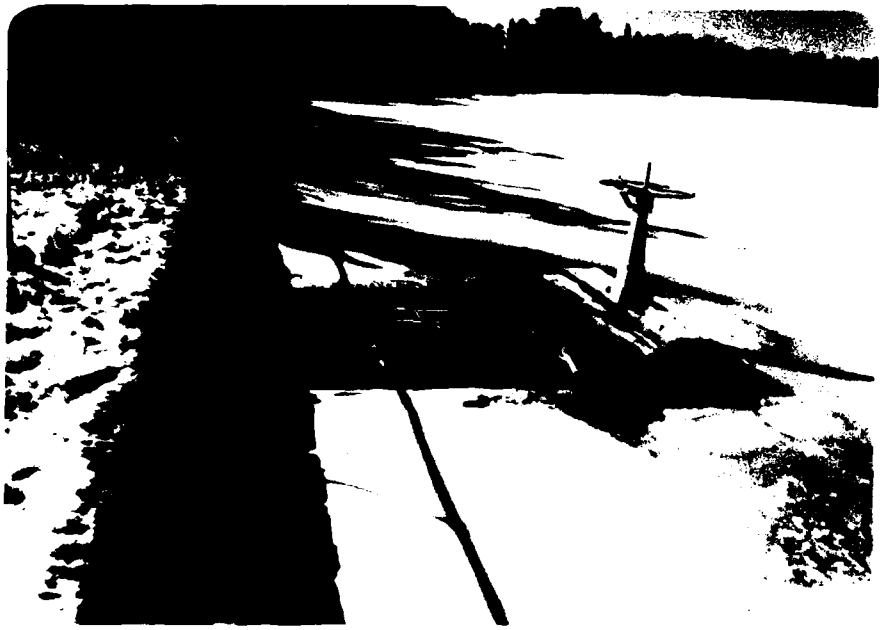


Photo 1 - View of spillway, lake and upstream slope of dam looking to the right. Note brush and small trees on slope.

Photo 2 - View of spillway, lake and upstream slope of dam looking to the left. Note brush and trees on slope.

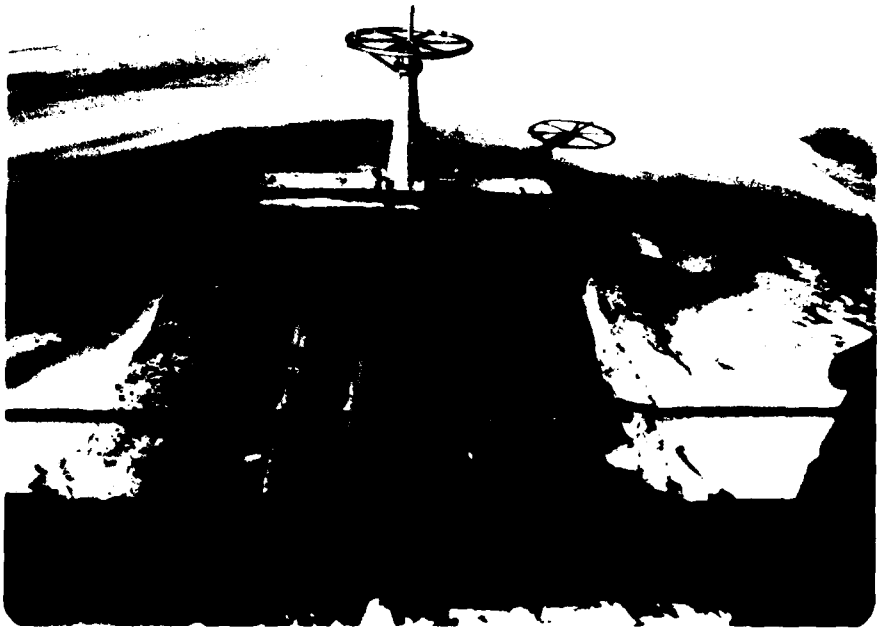


Photo 3 - View of spillway from top of dam.

Photo 4 - View of downstream slope looking from right of discharge channel (at bottom of picture). Note trees on slope.

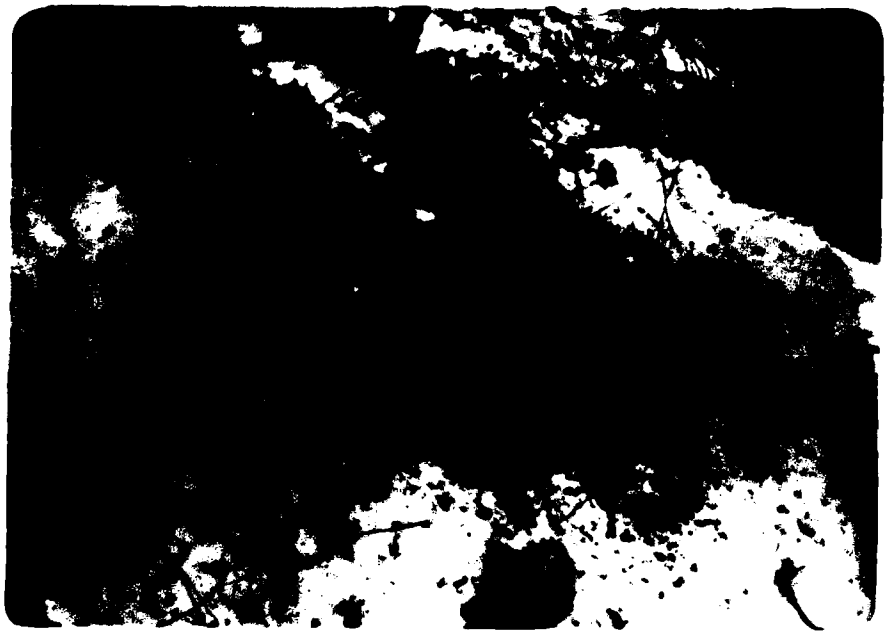


Photo 5 - Seepage area at downstream toe approximately 40 feet left of spillway.

Photo 6 - Seepage area at downstream toe at left end of dam. View is looking towards discharge channel with the embankment on the right.

Photo 7 - View of low-level outlet (60-inch x 66-inch R.C.P.) Note deterioration of timber headwall and erosion at the left side of pipe.

Photo 8 - View of downstream channel from top of embankment. Note roadway bridge in center.

Photo 9 - View of timber bridge where the downstream channel enters the lower lake.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: UPPER KESWICK DAM

Drainage Area Characteristics: 0.89 square miles

Elevation Top Normal Pool (Storage Capacity): 93.4 NGVD (54 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: 97.5 NGVD (SDF pool 148 acre-feet)

Elevation Top Dam: 96.66 NGVD (123 acre-feet)

SPILLWAY CREST:

a. Elevation 93.4 NGVD

b. Type Concrete Capped Timber Drop Inlet with notched front side.

c. Width 9.25 feet

d. Length 25.0 feet

e. Location Spillover Both sides and front

f. No. and Type of Gates None

OUTLET WORKS:

a. Type 60-inch x 66-inch R.C.P.

b. Location At spillway

c. Entrance Inverts 84.61 NGVD

d. Exit Inverts 83.43 NGVD

e. Emergency Draindown Facilities small sluice gate-60"x66" R.C.P.

HYDROMETEOROLOGICAL GAGES:

a. Type None

b. Location None

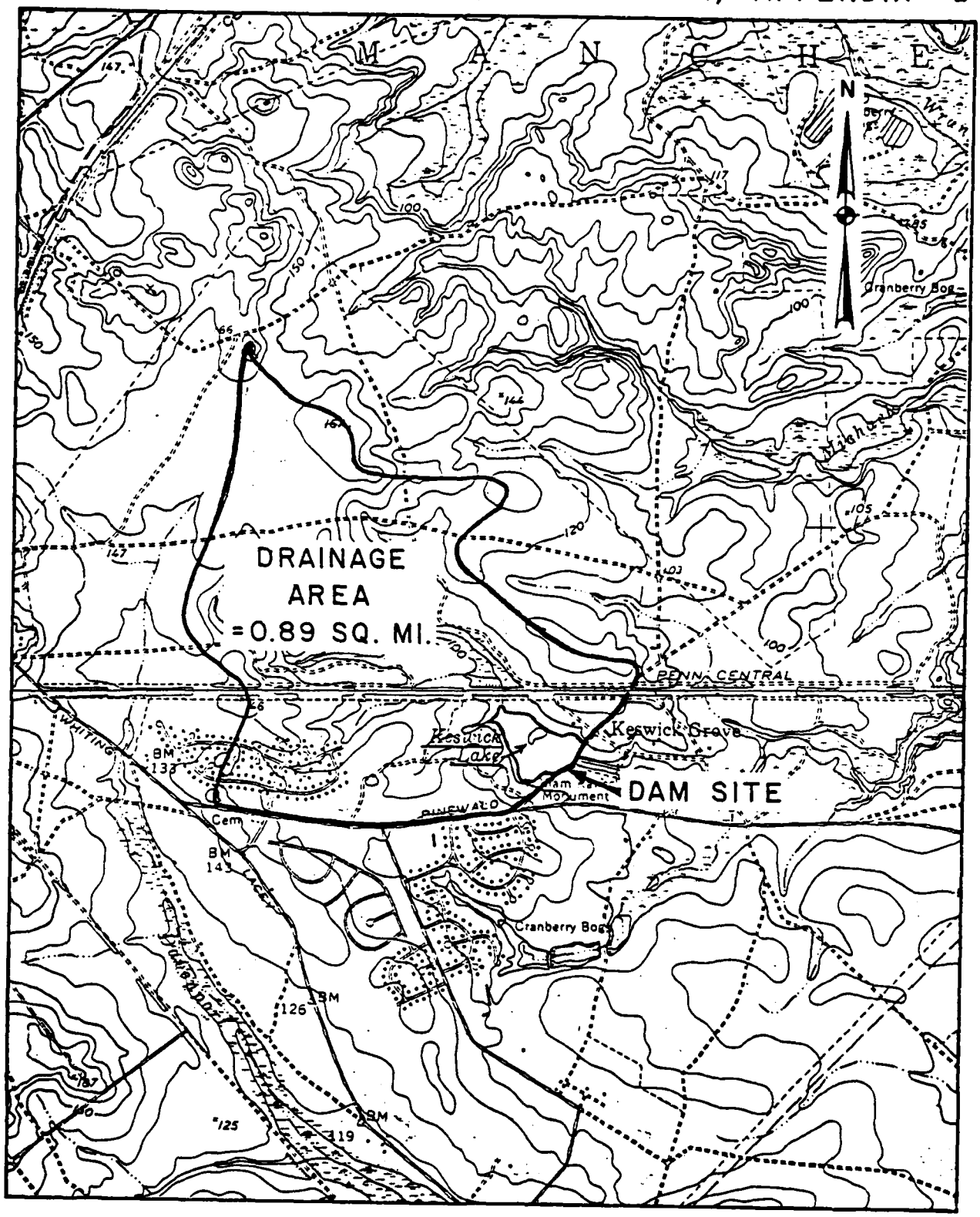
c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: 486 cfs at elevation 96.66 NGVD

APPENDIX D

HYDROLOGIC COMPUTATIONS

PLATE I, APPENDIX D



2,000 0 2,000 4,000

Scale: 1" = 2,000 FT.

UPPER KESWICK DAM
DRAINAGE BASIN

Area of the Lake at normal pool level

Area measured from U.S.G.S Quad (EL = 93.5)

= 16.53 AC

Height of the Dam = 96.66 - 84.28 ≃ 12.4 ft

Small Dam, High Hazard

S.D.F = $\frac{1}{2}$ PMF

Hydrologic Analysis:-

D.A = 0.89 sq miles

Inflow Hydrograph at Reservoir was determined using HEC 1 DB program. Inflow routed through the Lake

Elevation Area - Capacity Relationship

Information obtained from U.S.G.S

Ele	83.5	93.5	100	110
Surface Area(AC)	0	16.53	41.32	168.96

HEC - 1 DB program will develop storage capacity from surface area and elevation.

Determination of PMP

Probable Maximum ppt. (inches) for an area of 10 square miles and 6 hour duration
= 26"

D.A = '89 sq miles

ZONE = C

The corps of Engineers recommended that 20 % reduction to be applied to the report value for a 10 sq miles drainage area in order to provide for the imperfect fit of the storm isohyetal patterns to the shape of the particular basin.

Because of the unlikelihood of a perfect strike of a storm center on any particular small basin, no variation is assumed between point and 10 square miles precipitation

P.M.P = 26" x (1-0.2) = 20.8" (This reduction is done by the HEC 1 DB Program

Depth area duration relationship.
Percentage to be applied to the above 6 hr PMP

6 hr = 100 %
12 hr = 108 %
24 hr = 117 %
48 hr = 127 % (Not neccessary)

INFILTRATON :- High (Discussed with local people during inspection)
Initial Infiltration = 1.5 inch
Const infiltration = .15 inch/hr.

DETERMINATION OF Tc

1. Estimating Tc from velocity estimate and Watercourse length. (Ref: Design of Small Dam Fig 30)

	Slope	Vel	Remarks
Overland flow	$\frac{167-140}{2400} \times 100 = 1.125\%$	1.5	upper portion of watershed
Reach 1	$\frac{140-95}{5600} \times 100 = .80\%$	1.0	Natural Channel (Neglect flow Through Lake)

$$Tc = \frac{2400}{1.5 \times 3600} + \frac{5600}{1 \times 3600}$$

$$= 2.0 \text{ hrs.}$$

2. Estimating Tc assuming same velocity

$$Tc = \frac{8000}{1 \times 3600} = 2.22 \text{ hrs.}$$

3. From Nomograph of design of Small Dam (S.C.S. Guide) — same as Kirpich

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{.385}$$

L in miles = 1.52 miles (Lake excluded)

H in ft = 72 ft

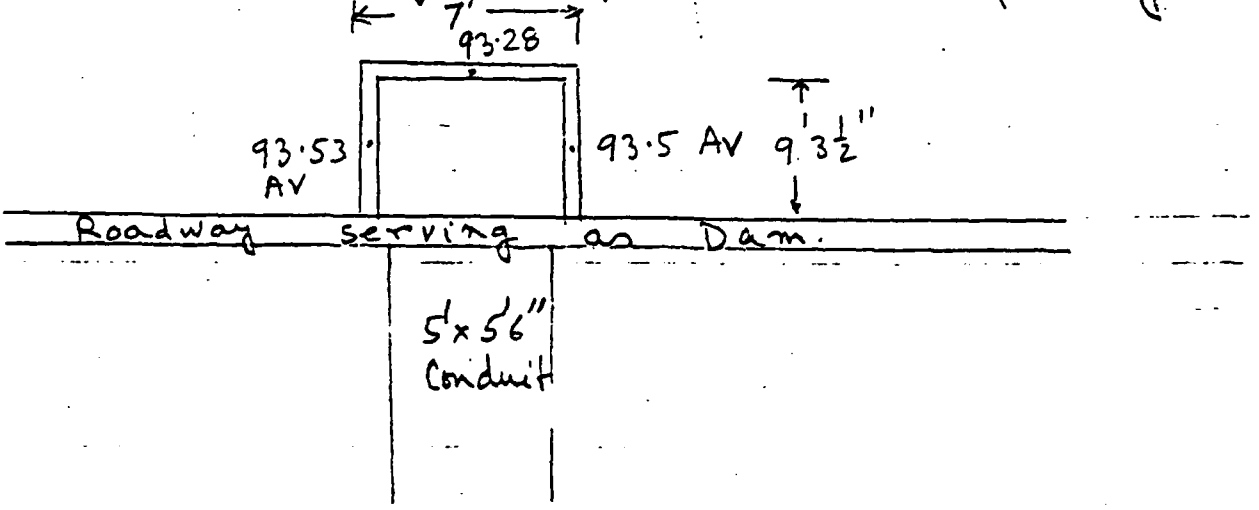
$$= \left[\frac{11.9 \times (1.52)^3}{72}\right]^{.385}$$

$$= .81 \text{ hrs.}$$

Use Tc = 2 hrs.

Lag = $0.6 \times 2 = 1.2$ hrs.

Schematic Diagram of Dam and Spillway



Water is entering through three sides of the box type spillway.

Total Length of Spillway = 25.5 Ft
Average Top of Spillway = 93.44 ft

Length of Dam = 177 + 119 − 7 = 289 Ft
Top of Dam = 96.66

Flow over the spillway $Q_s = C_1 L_1 H_1^{3/2}$

$C_1 = 3.3$ $L_1 = 25.5$

Flow over the Dam $Q_D = C_2 L_2 H_2^{3/2}$

$L_2 = 2.75$ $L_2 = 289$

Full Normal Capacity of the pipe

Pipe is approximately circular (5'6" × 5'0") of dia 5.25 Ft.

$R = \frac{5.25}{4} = 1.3125$ Ft $\quad R^{2/3} = 1.2$

$A = \frac{\pi}{4} \times (5.25)^2 = 21.65$ sqft.

$S = \frac{84.28 - 83.43}{45} = .01888$

$S^{\frac{1}{2}} = .1374$

$Q_f = \frac{1.486}{.013} \times 1.2 \times .01888 \times 21.65 = 56$ cfs

Considering Pressure flow Conduit

$Q = \frac{1.486}{n} R^{2/3} \sqrt{S_f} \times A \qquad L = 45$

$= \frac{1.486}{.013} \times 1.2 \times 21.65 \times \frac{\sqrt{h}}{\sqrt{L}}$

$= 442.7 \sqrt{h}$

Tailwater Depth is assumed as the D/s reservoir el
= 84.76

PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Upper Kenwick Dam
COMPUTED BY S.B. CHECKED BY

SHEET NO. 6 OF
JOB NO. 10-1176-07
DATE Feb, 1981

Elevation	SPILLWAY CONTOL H_1 Ht over spillway	Q_s $84.15 H_1^{3/2}$	PIPE CONTROL h_p	Q_p $442.7\sqrt{h_p}$
93.44	—	—	8.68	1304
95	1.56	164	10.24	1417
96.66	3.22	486	11.9	1527
97	3.56	563	12.24	1549
99	5.56	1103	14.24	1670
101	7.56	1749	16.24	1784
103	9.56	2487	18.24	1891
105	11.56	3307	20.24	1992
107	13.56	4202	22.24	2088

It is observed that upto elevation 101 it is spillway control after that it is pipe control

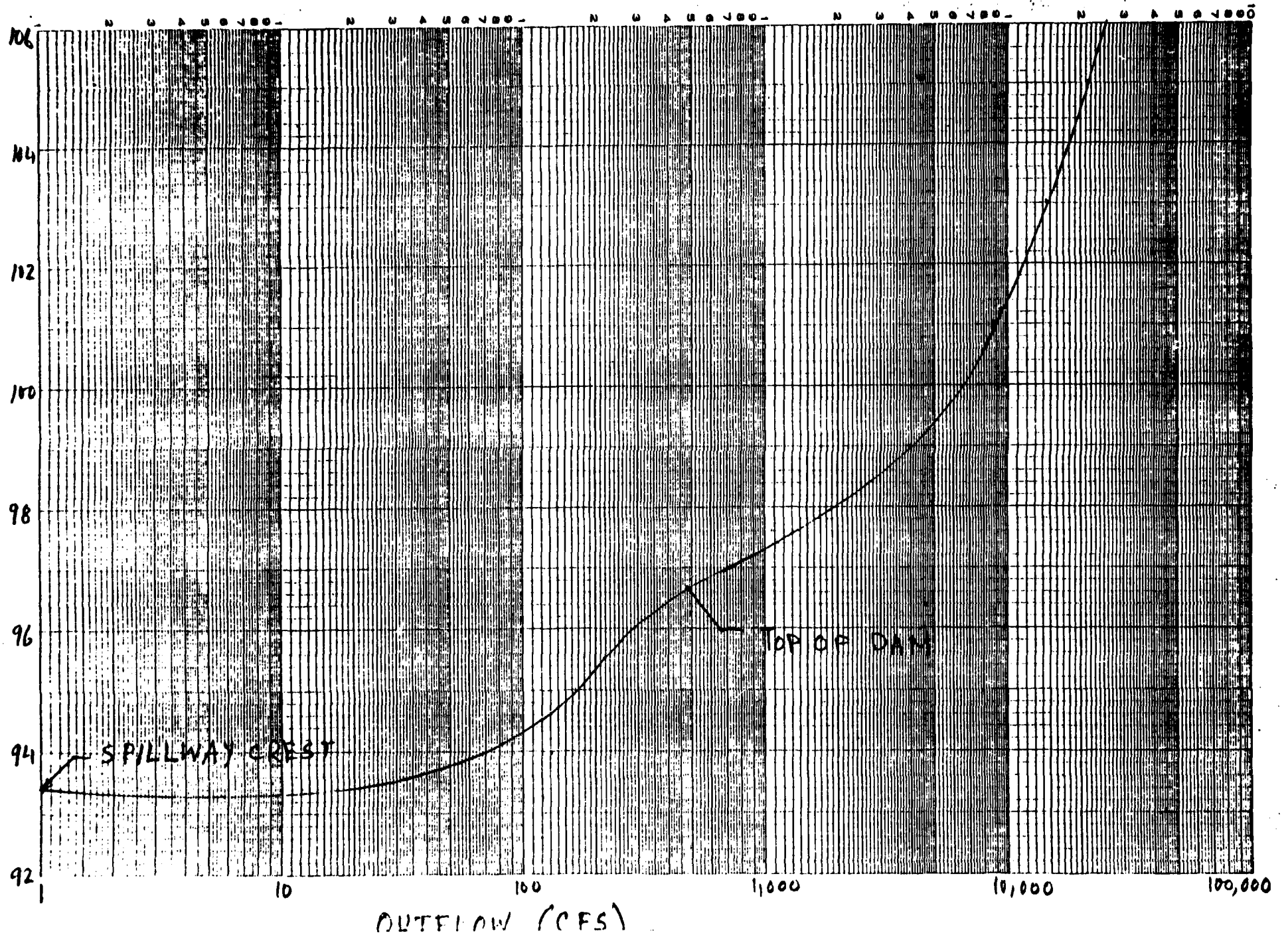
PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Upper Kensuick Dam
COMPUTED BY S.B CHECKED BY

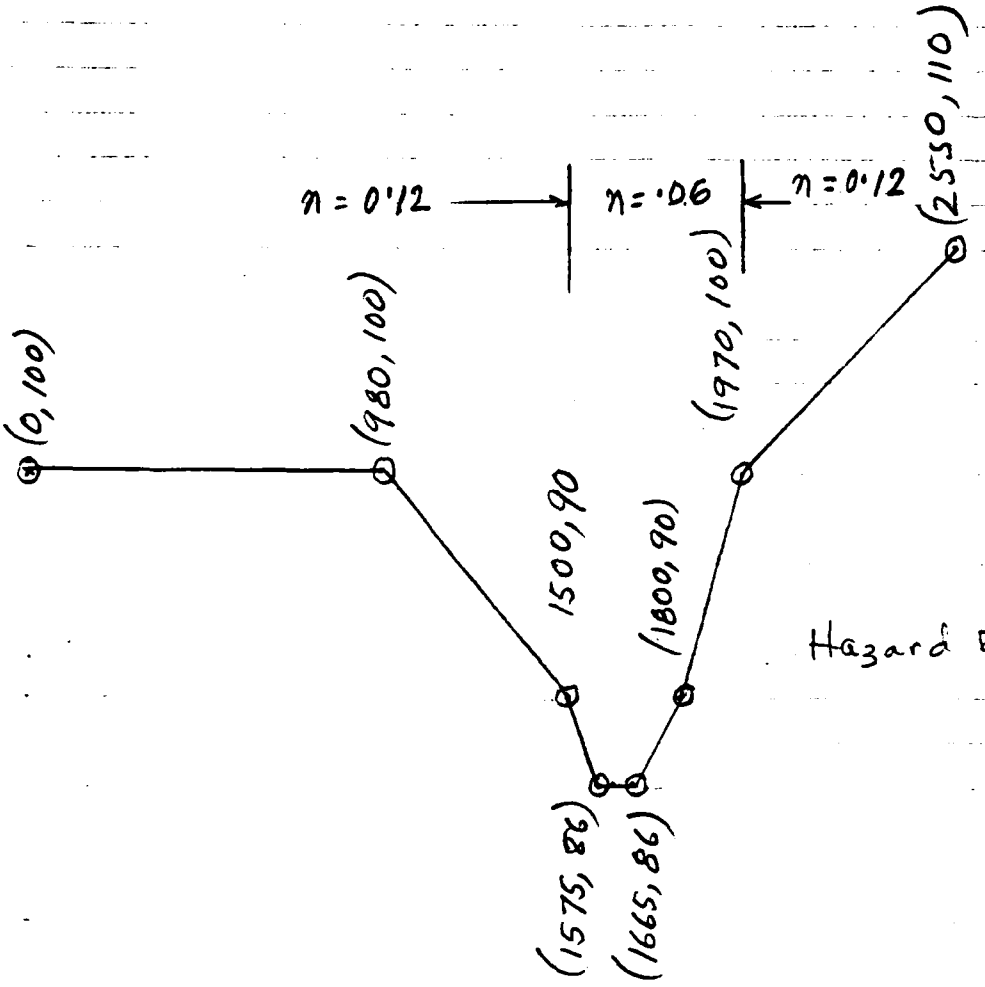
SHEET NO. 7 OF
JOB NO. 10-1176-01
DATE Feb 1981

FINAL RATING CURVE

Elevation	Flow Thro Spillway	Ht over Dam H_D	Flow over Dam $794.75 H_D^{3/2}$	Total Flow
93.44	0			0
95	164			164
96.66	486	0	0	486
97	563	.34	157	720
99	1103	2.34	2,845	3,948
101	1749	4.34	7,186	8,935
103	1891	6.34	12,687	14,578
105	1992	8.34	19,142	21,134
107	2088	10.34	26,425	28,513



Cross Section at D/S Reach



Hazard Elev. = 86. (Est.)

REACH 1

$L = 700$ Ft

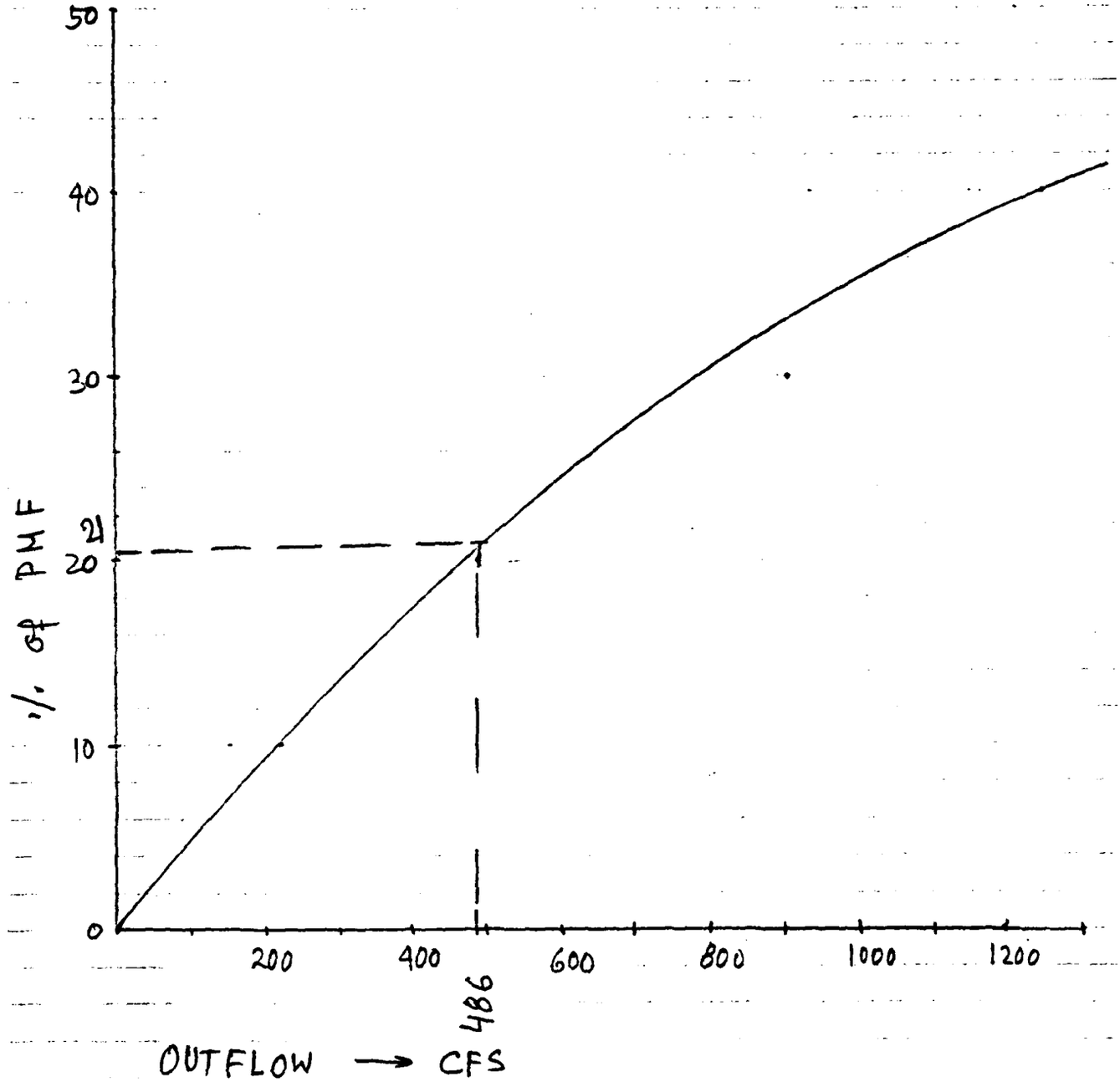
$S = \frac{20}{2000} = .01$

PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Upper Kenswick Dam
COMPUTED BY S.B. CHECKED BY

SHEET NO. 10 OF
JOB NO. 10-1176-01
DATE Feb, 1981

Overtopping Potential

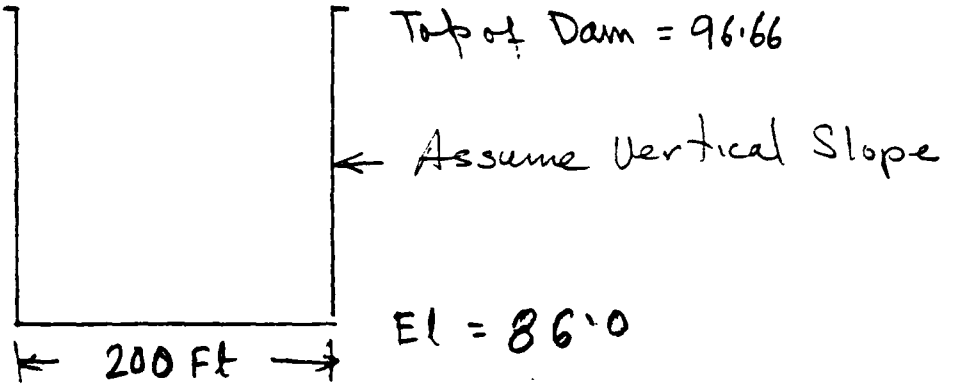


Overtopping of Dam occurs at El = 96.66

Q = 486 at 21 % of PMF

Breach Analysis

Assume breach begins to develop when reservoir stage reaches above the dam.
Time of Failure = 16.75 hrs



Effect of breach was analysised at 700 Ft D/S of Dam.

Maximum stage without Dam break = 87.8

Maximum stage with Dam break = 89.8

There will be 2.0 Ft increase in stage due to Dam failure. at 0.3 PMP

```
***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
***********************************
     1        A       N.J..  DAM INSPECTION
     2        A2      UPPER KESWICK DAM
     3        A3      MULTI RATIO PMF ROUTING
     4        B    100      0     15      0      0      0      0      0      0      0
     5        B1     5
     6        J      1      5      1
     7        J1    .5     .4     .3     .2     .1
     8        K      0    RES                                  1
     9        K1      LOCAL INFLOW
    10        M      1      2    .09           .09
    11        P      0     26    100    106    117
    12        T                                              1.5    .15           .02
    13        W2           1.2
    14        X     -1   -.06      2
    15        K      1    DAM                                  1
    16        K1      ROUTING THROUGH DAM
    17        Y                                1      1
    18        Y1     1                                      -93.44     -1
    19        Y4 93.44     95  96.46     97     99    101    103    105    107
    20        Y5     0    164    486    720   3548   8935  14578  21134  28513
    21        $A     0  16.53  41.32 168.96
    22        $E  83.5   93.5    100    110
    23        $$ 93.44
    24        $D 96.66
    25        K      1  REACH1                                 1
    26        K1      CHANNEL ROUTING BY MOD. PULS  REACH 1
    27        Y                                1      1
    28        Y1     1
    29        Y6   .12    .06    .12     86    110    700    .01
    30        Y7     0    100    960    100   1500     50   1575     86   1665     86
    31        Y7  1800     90   1970    100   2050    110
    32        K     99
```

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN DATE:  TUE, APR 07 1981
TIME:  09:14:37

                    N.J.. DAM INSPECTION
                    UPPER KESWICK DAM
                    MULTI RATIO PMF ROUTING

                              JOB SPECIFICATION
     NQ     NHR     NMIN     IDAY     IHR     IMIN    METRC    IPLT    IPRT   USTAN
    100       0       15        0       0        0        0       0       0       0
                              JOPER     NWT   LROPT   TRACE
                                  5       0       0       0

                    MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1  NRTIO= 5  LRTIO= 1
                    RTIOS=  0.50    0.40    0.30    0.20    0.10

**********    **********    **********    **********    **********

                    SUB-AREA RUNOFF COMPUTATION

                    LOCAL INFLOW
                    ISTAQ   ICOMP   IECON   ITAPE   JPLT    JPRT   INAME  ISTAGE  IAUTO
                      RES       0       0       0       0       1       0       0

                    HYDROGRAPH DATA
                    IHYDG   IUHG   TAREA    SNAP   IRSD   IRSPC   RATIO   ICNOW   ISAME   LOCAL
                        1      2   0.80     0.0    0.60   0.00    0.300                0       0

                    PRECIP DATA
                    SPFE    PMS     R6      R12     R24     R48     R72     R96
                    0.00    26.00   100.00  108.00  117.00  0.00    0.00    0.00
EXCESS COMPUTED BY THE PROGRAM IS 0.800

                    LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0    0.00    0.00    1.00    1.00    0.00    1.00    1.50    0.15    0.00    0.02

                    UNIT HYDROGRAPH DATA
                    TC=  0.00    LAG=  1.20

                    RECESSION DATA
                    STRTQ=  -1.00    QRCSN=  -0.05    RTIOR= 2.00

     UNIT HYDROGRAPH 36 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   1.20  VOL= 1.00
        50.     92.    144.    146.    123.    315.    274.    217.    150.    110.
        82.     61.     44.     33.     24.     17.     13.      9.      7.      5.
         4.      3.      2.      2.      1.      0.

                    END-OF-PERIOD FLOW
     0
   MO.DA   HR.MN   PERIOD   RAIN   EXCS   LOSS   COMP Q     MO.DA   HR.MN   PERIOD   RAIN   EXCS   LOSS   COMP Q
    1.01    0.15        1   0.03   0.00   0.03      1.      1.01    1.45       51   0.83   0.44   0.24     215.
    1.01    0.30        2   0.05   0.00   0.05      1.      1.01   15.00       52   0.52   0.44   0.24     245.
    1.01    0.45        3   0.05   0.00   0.05      1.      1.01   15.15       53   0.62   0.54   0.24     283.
```

		6	0.03	0.00	0.03	1.	1.01	17.30	59	0.62	0.59	0.04	949.
		7	0.03	0.00	0.03	1.	1.01	17.45	60	0.62	0.59	0.04	916.
		8	0.03	0.00	0.03	1.	1.01	18.00	61	0.62	0.59	0.04	916.
		9	0.03	0.00	0.03	1.	1.01	18.15	62	0.78	0.74	0.04	1322.
		A	0.03	0.00	0.03	2.	1.01	18.30	63	0.78	0.74	0.04	1319.
		B	0.03	0.00	0.03	2.	1.01	18.45	64	0.78	0.74	0.04	1314.
1.01	9.00	10	0.03	0.00	0.03	2.	1.01	19:00	65	0.78	0.74	0.04	1309.
1.01	9.15	11	0.03	0.00	0.03	2.	1.01	19.15	66	0.79	0.75	0.04	1395.
1.01	9.30	12	0.03	0.00	0.03	2.	1.01	19.30	67	1.58	1.54	0.04	1495.
1.01	9.45	13	0.03	0.00	0.03	2.	1.01	19.45	68	4.43	4.39	0.04	1717.
1.01	9.00	14	0.03	0.00	0.03	2.	1.01	20.00	69	1.11	1.07	0.04	2062.
1.01	10.15	15	0.03	0.00	0.03	2.	1.01	20.15	70	0.73	0.69	0.04	2579.
1.01	10.30	16	0.03	0.00	0.03	2.	1.01	20.30	71	0.73	0.69	0.04	2799.
1.01	10.45	17	0.03	0.00	0.03	2.	1.01	20.45	72	0.73	0.69	0.04	3166.
1.01	11.00	18	0.03	0.00	0.03	2.	1.01	21.00	73	0.73	0.69	0.04	3115.
1.01	11.15	19	0.03	0.00	0.03	2.	1.01	21.15	74	0.57	0.54	0.04	2004.
1.01	11.30	20	0.03	0.00	0.03	2.	1.01	21.30	75	0.57	0.54	0.04	2607.
1.01	11.45	21	0.03	0.00	0.03	2.	1.01	21.45	76	0.57	0.54	0.04	2272.
1.01	12.00	22	0.03	0.00	0.03	2.	1.01	22.00	77	0.57	0.54	0.04	2029.
1.01	12.15	23	0.03	0.00	0.03	2.	1.01	22.15	78	0.05	0.01	0.04	1827.
1.01	12.30	24	0.03	0.00	0.03	2.	1.01	22.30	79	0.05	0.01	0.04	1627.
1.01	12.45	25	0.07	0.00	0.07	2.	1.01	22.45	80	0.05	0.01	0.04	1403.
1.01	13.00	26	0.07	0.00	0.07	2.	1.01	23.00	81	0.05	0.01	0.04	1162.
1.01	13.15	27	0.07	0.00	0.07	2.	1.01	23.15	82	0.05	0.01	0.04	926.
1.01	13.30	28	0.07	0.00	0.07	2.	1.01	23.30	83	0.05	0.01	0.04	712.
1.01	13.45	29	0.07	0.00	0.07	2.	1.01	23.45	84	0.05	0.01	0.04	535.
1.01	14.00	30	0.07	0.00	0.07	2.	1.02	0.00	85	0.05	0.01	0.04	393.
1.01	14.15	31	0.07	0.00	0.07	2.	1.02	0.15	86	0.05	0.01	0.04	295.
1.01	14.30	32	0.07	0.00	0.07	2.	1.02	0.30	87	0.05	0.01	0.04	224.
1.01	14.45	33	0.07	0.00	0.07	2.	1.02	0.45	88	0.05	0.01	0.04	170.
1.01	15.00	34	0.07	0.00	0.07	2.	1.02	1.00	89	0.05	0.01	0.04	151.
1.01	15.15	35	0.07	0.01	0.06	3.	1.02	1.15	90	0.05	0.01	0.04	141.
1.01	15.30	36	0.07	0.03	0.04	9.	1.02	1.30	91	0.05	0.01	0.04	131.
1.01	15.45	37	0.07	0.03	0.04	8.	1.02	1.45	92	0.05	0.01	0.04	123.
1.01	16.00	38	0.07	0.03	0.04	14.	1.02	2.00	93	0.05	0.01	0.04	114.
1.01	16.15	39	0.07	0.03	0.04	24.	1.02	2.15	94	0.05	0.01	0.04	107.
1.01	16.30	40	0.07	0.03	0.04	34.	1.02	2.30	95	0.05	0.01	0.04	100.
1.01	16.45	41	0.07	0.03	0.04	46.	1.02	2.45	96	0.05	0.01	0.04	93.
1.01	17.00	42	0.07	0.03	0.04	62.	1.02	3.00	97	0.00	0.00	0.00	87.
1.01	17.15	43	0.07	0.03	0.04	58.	1.02	3.15	98	0.00	0.00	0.00	81.
1.01	17.30	44	0.07	0.03	0.04	62.	1.02	3.30	99	0.00	0.00	0.00	75.
1.01	17.45	45	0.07	0.03	0.04	66.	1.02	3.45	100	0.00	0.00	0.00	70.
1.01	18.00	46	0.07	0.03	0.04	68.	1.02	4.00	101	0.00	0.00	0.00	66.
1.01	18.15	47	0.07	0.03	0.04	70.	1.02	4.15	102	0.00	0.00	0.00	61.
1.01	18.30	48	0.07	0.03	0.04	71.	1.02	4.30	103	0.00	0.00	0.00	57.
1.01	18.45	49	0.52	0.48	0.04	87.	1.02	4.45	104	0.00	0.00	0.00	53.
1.01	19.00	50	0.52	0.48	0.04	128.	1.02	5.00	105	0.00	0.00	0.00	50.

SUM 24.34 20.42 3.72 48118.
(618.1(524.1(94.1(1362.49)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3166.	1765.	901.	881.	48086.
CMS	90.	50.	14.	14.	1362.
INCHES		10.44	20.94	20.94	20.94
MM		468.50	531.89	531.92	531.92
AC-FT		870.	994.	994.	994.
THOUS CU M		1074.	1225.	1225.	1225.

HYDROGRAPH AT STA RES FOR PLAN 1, RTIO 1

0.	0.	0.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	2.	2.	4.	7.	12.	17.		
22.	28.	36.	31.	37.	34.	25.	36.	45.	64.	

FLOOD HYDROGRAPH PACKAGE (HEC-1) PERIOD SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5
				0.50	0.40	0.30	0.20	0.10
HYDROGRAPH AT	REACH	3.19	1	1581.	1264.	950.	633.	317.
		(8.31)		(44.81)	(35.80)	(26.90)	(17.93)	(8.97)
ROUTED TO	DAM	0.19	1	1581.	1231.	859.	446.	211.
		(7.31)		(43.62)	(34.87)	(24.33)	(12.63)	(5.97)
ROUTED TO	REACH	0.19	1	1581.	1218.	851.	446.	211.
		(7.31)		(43.62)	(34.51)	(24.09)	(12.63)	(5.97)

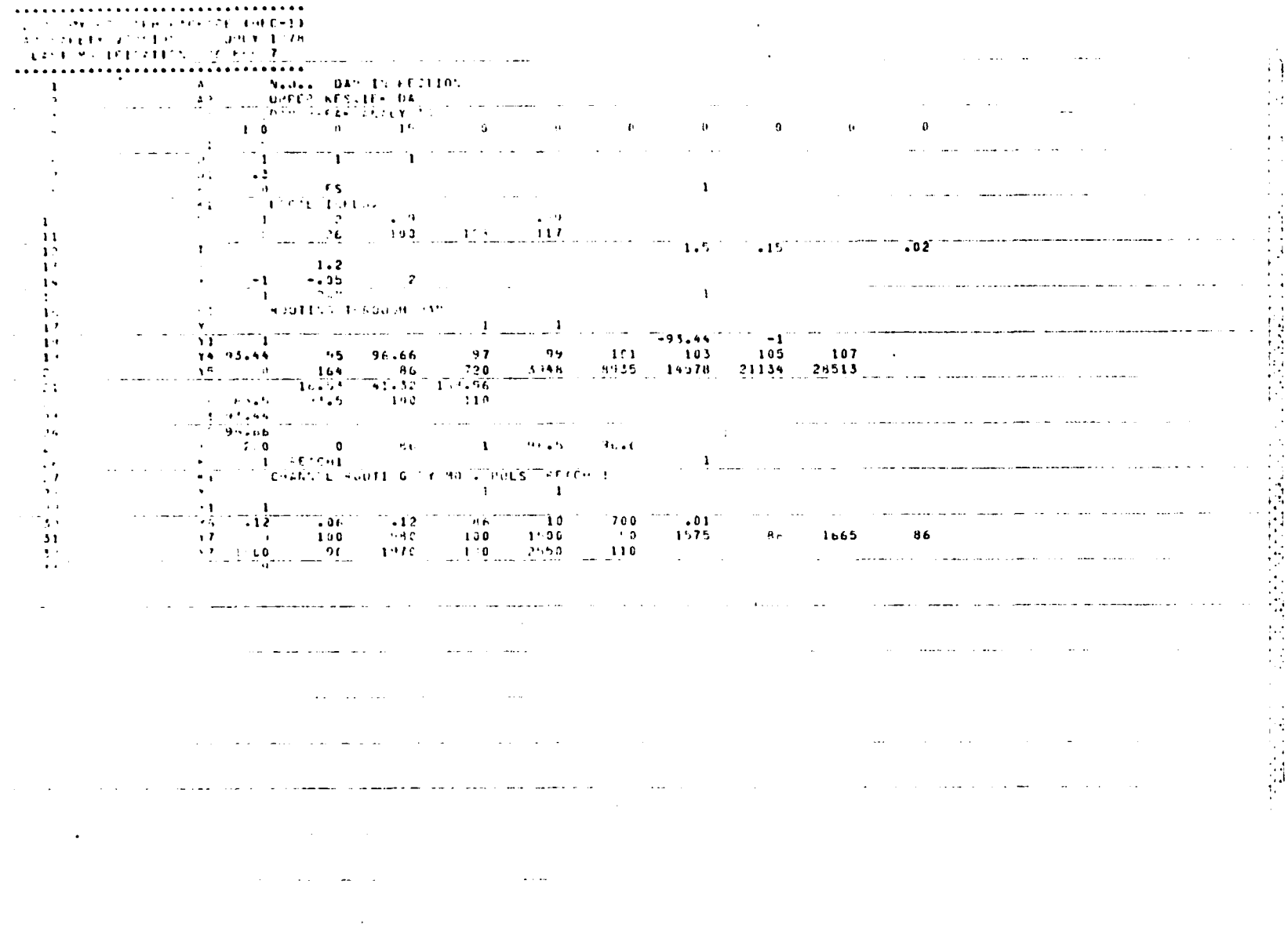
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	93.44	93.44	96.66
	STORAGE	54.	94.	123.
	OUTFLOW	0.	0.	486.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	97.51	0.85	141.	1581.	4.00	17.00	0.00
0.40	97.31	0.65	142.	1231.	3.25	17.00	0.00
0.30	97.05	0.45	135.	859.	2.25	17.25	0.00
0.20	96.45	0.01	114.	446.	0.00	17.75	0.00
0.10	96.24	0.00	99.	211.	0.00	18.00	0.00

PLAN 1 STATION REACH

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.50	1581.	89.6	17.00
0.40	1218.	88.3	17.00
0.30	851.	87.6	17.50
0.20	446.	87.3	17.75
0.10	211.	86.7	18.00



FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

RUN DATE: MON APR 07 1981
TIME: 13:09:47

N.J.. DAM INSPECTION
UPPER KESWICK DAM
DAM BREAK ANALYSIS

JOB SPECIFICATION

IT	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
170	0	15	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= 0.30

SUB-AREA RUNOFF COMPUTATION

LOCAL INFLOW

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
RES	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	0.09	0.0	0.09	0.00	0.000		0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.00	100.00	109.00	117.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LOSS	STRKR	DLTKR	RTIOL	STRTL	CNSTL	RTIOK	STRTK	CNSTK	ALSMX	RTIMP
2	0.00	0.00	1.00	0.00	0.00	1.00	1.50	0.15	0.00	0.02

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.20

RECESSION DATA
STRTQ= +1.00 QRCSN= -0.05 RTIOR= 2.00

UNIT HYDROGRAPH 26 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.20 VOL= 1.00

10.	43.	103.	206.	323.	315.	274.	217.	150.	110.	
73.	61.	44.	33.	24.	17.	13.	9.	7.	5.	
4.	3.	2.	2.	1.	0.					

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	0.15	1	0.05	0.00	0.05	1.	1.01	13.45	51	0.52	0.48	0.04	215.
1.01	0.30	2	0.05	0.00	0.05	1.	1.01	14.00	52	0.52	0.48	0.04	345.
1.01	0.45	3	0.05	0.00	0.05	1.	1.01	14.15	53	0.62	0.58	0.04	493.

1.01	1.00	4	0.03	0.00	0.03	1.	1.01	15.30	54	0.62	0.59	0.04	845.
1.01	1.15	5	0.03	0.00	0.03	1.	1.01	15.45	55	0.62	0.59	0.04	789.
1.01	1.30	6	0.03	0.00	0.03	1.	1.01	16.00	56	0.62	0.59	0.04	916.
1.01	1.45	7	0.03	0.00	0.03	1.	1.01	16.15	57	0.78	0.74	0.04	1022.
1.01	2.00	8	0.03	0.00	0.03	2.	1.01	16.30	58	0.78	0.74	0.04	1119.
1.01	2.15	9	0.03	0.00	0.03	2.	1.01	16.45	59	0.78	0.74	0.04	1214.
1.01	2.30	10	0.03	0.00	0.03	2.	1.01	17.00	60	0.78	0.74	0.04	1309.
1.01	2.45	11	0.03	0.00	0.03	2.	1.01	17.15	61	0.79	0.75	0.04	1395.
1.01	3.00	12	0.03	0.00	0.03	2.	1.01	17.30	62	1.58	1.54	0.04	1495.
1.01	3.15	13	0.03	0.00	0.03	2.	1.01	17.45	63	4.43	4.39	0.04	1717.
1.01	3.30	14	0.03	0.00	0.03	2.	1.01	18.00	64	1.11	1.07	0.04	2062.
1.01	3.45	15	0.03	0.00	0.03	2.	1.01	18.15	65	0.73	0.69	0.04	2579.
1.01	4.00	16	0.03	0.00	0.03	2.	1.01	18.30	66	0.73	0.69	0.04	2999.
1.01	4.15	17	0.03	0.00	0.03	2.	1.01	18.45	67	0.73	0.69	0.04	3166.
1.01	4.30	18	0.03	0.00	0.03	2.	1.01	19.00	68	0.73	0.69	0.04	3115.
1.01	4.45	19	0.03	0.00	0.03	2.	1.01	19.15	69	0.57	0.54	0.04	2904.
1.01	5.00	20	0.03	0.00	0.03	2.	1.01	19.30	70	0.57	0.54	0.04	2607.
1.01	5.15	21	0.03	0.00	0.03	2.	1.01	19.45	71	0.57	0.54	0.04	2272.
1.01	5.30	22	0.03	0.00	0.03	2.	1.01	20.00	72	0.57	0.54	0.04	2029.
1.01	5.45	23	0.03	0.00	0.03	3.	1.01	20.15	73	0.05	0.01	0.04	1827.
1.01	6.00	24	0.03	0.00	0.03	2.	1.01	20.30	74	0.05	0.01	0.04	1627.
1.01	6.15	25	0.07	0.00	0.07	2.	1.01	20.45	75	0.05	0.01	0.04	1403.
1.01	6.30	26	0.07	0.00	0.07	2.	1.01	21.00	76	0.05	0.01	0.04	1162.
1.01	6.45	27	0.07	0.00	0.07	2.	1.01	21.15	77	0.05	0.01	0.04	926.
1.01	7.00	28	0.07	0.00	0.07	2.	1.01	21.30	78	0.05	0.01	0.04	712.
1.01	7.15	29	0.07	0.00	0.07	2.	1.01	21.45	79	0.05	0.01	0.04	533.
1.01	7.30	30	0.07	0.00	0.07	2.	1.01	22.00	80	0.05	0.01	0.04	393.
1.01	7.45	31	0.07	0.00	0.07	3.	1.01	22.15	81	0.05	0.01	0.04	285.
1.01	8.00	32	0.07	0.00	0.07	3.	1.01	22.30	82	0.05	0.01	0.04	224.
1.01	8.15	33	0.07	0.00	0.07	3.	1.01	22.45	83	0.05	0.01	0.04	170.
1.01	8.30	34	0.07	0.00	0.07	3.	1.01	23.00	84	0.05	0.01	0.04	151.
1.01	8.45	35	0.07	0.01	0.06	3.	1.01	23.15	85	0.05	0.01	0.04	141.
1.01	9.00	36	0.07	0.03	0.04	5.	1.01	23.30	86	0.05	0.01	0.04	131.
1.01	9.15	37	0.07	0.03	0.04	8.	1.01	23.45	87	0.05	0.01	0.04	125.
1.01	9.30	38	0.07	0.03	0.04	14.	1.02	0.00	88	0.05	0.01	0.04	114.
1.01	9.45	39	0.07	0.03	0.04	24.	1.02	0.15	89	0.05	0.01	0.04	107.
1.01	10.00	40	0.07	0.03	0.04	34.	1.02	0.30	90	0.05	0.01	0.04	100.
1.01	10.15	41	0.07	0.03	0.04	43.	1.02	0.45	91	0.05	0.01	0.04	93.
1.01	10.30	42	0.07	0.03	0.04	52.	1.02	1.00	92	0.05	0.01	0.04	87.
1.01	10.45	43	0.07	0.03	0.04	58.	1.02	1.15	93	0.05	0.01	0.04	81.
1.01	11.00	44	0.07	0.03	0.04	62.	1.02	1.30	94	0.05	0.01	0.04	75.
1.01	11.15	45	0.07	0.03	0.04	66.	1.02	1.45	95	0.05	0.01	0.04	70.
1.01	11.30	46	0.07	0.03	0.04	68.	1.02	2.00	96	0.05	0.01	0.04	66.
1.01	11.45	47	0.07	0.03	0.04	70.	1.02	2.15	97	0.00	0.00	0.00	61.
1.01	12.00	48	0.07	0.03	0.04	71.	1.02	2.30	98	0.00	0.00	0.00	57.
1.01	12.15	49	0.52	0.48	0.04	86.	1.02	2.45	99	0.00	0.00	0.00	53.
1.01	12.30	50	0.52	0.48	0.04	124.	1.02	1.00	100	0.00	0.00	0.00	50.
									SUM	24.39	20.62	3.72	88116.
										(.618,)(.524.)(.94.)(1362.49)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3166.	1765.	501.	491.	88086.
CMS	90.	50.	14.	14.	1362.
INCHES		10.44	20.96	20.94	20.94
MM		469.50	531.89	531.92	531.92
AC-FT		875.	993.	994.	994.
THOUS CU M		1079.	1225.	1225.	1225.

HYDROGRAPH AT STA RES FOR PLAN 1, RATIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	1.	1.	1.	1.	1.	1.	1.	0.	0.
0.	0.	0.	0.	0.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	2.	4.	7.	10.
14.	15.	17.	19.	20.	20.	21.	21.	36.	38.

STATION DAM

TIME (HRS) — (O) INTERPOLATED BREACH HYDROGRAPH (B) COMPUTED BREACH HYDROGRAPH — (+) POINTS AT NORMAL TIME INTERVAL

TIME (HRS)	0.	400.	800.	1200.	1600.	2000.	2400.	2800.	3200.	3600.	0.	0.	0.	0.
16.75	1.													
16.77	2.													
16.79	3.													
16.81	4.													
16.83	5.													
16.85	6.													
16.87	7.													
16.88	8.													
16.90	9.													
16.92	10.													
16.94	11.													
16.96	12.													
16.98	13.													
17.00	14.													
17.02	15.													
17.04	16.													
17.06	17.													
17.08	18.													
17.10	19.													
17.12	20.													
17.15	21.													
17.15	22.													
17.17	23.													
17.19	24.													
17.21	25.													
17.23	26.													
17.25	27.													
17.27	28.													
17.29	29.													
17.31	30.													
17.33	31.													
17.35	32.													
17.37	33.													
17.39	34.													
17.40	35.													
17.42	36.													
17.44	37.													
17.46	38.													
17.48	39.													
17.50	40.													
17.52	41.													
17.54	42.													
17.56	43.													
17.58	44.													
17.60	45.													
17.62	46.													
17.63	47.													
17.65	48.													
17.67	49.													
17.69	50.													
17.71	51.													
17.73	52.													
17.75	53.													

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	RATIOS APPLIED TO FLOWS
				0.30	
HYDROGRAPH AT	MES	0.09 (2.31)	1	350. (9.91)	
ROUTED TO	DAM	0.09 (2.31)	1	1252. (35.46)	
ROUTED TO	REACH1	0.09 (2.31)	1	3347. (94.78)	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	95.00	95.44	95.66
	STORAGE	119.	54.	123.
	OUTFLOW	455.	0.	486.

PLAN	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.30	96.62	0.18	121.	3259.	0.40	17.25	16.75

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.30	3347.	89.8	17.25

549.2 24.00